PERSONAL COMPUTER DIVISION
WHITE PAPER

HOME COMPUTER

TEXAS INSTRUMENTS
INCORPORATED

CONSUMER ELECTRONICS BUSINESS OBJECTIVE

PERSONAL COMPUTER STRATEGY

TEXAS INSTRUMENTS HOME COMPUTER
WHITE PAPER

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1.0 INTRODUCTION

1.1 FOREWARD AND KEY FACTORS

Central focus of this "White Paper" is a description of approaches that are being pursued to insure that the Home Computer is a success in the marketplace and a profitable business for TI. Included in the paper are details to support the following statements:

- Our understanding of the user is correct
- Our approach to user education is correct
- Our retail price structure is right
- Our software packages are being defined properly
- Our system definition and peripheral strategy is correct
- The chip set is manufacturable
- The system reliability is adequate
- The system will pass FCC regulations
- The home security and control strategy is correct
- Our manufacturing cost estimates are consvertive

This White Paper is intended to serve as a stand alone update to the Home Computer discussion contained in the May 6, 1978 White Paper describing the complete Personal Computer product line.

1.2 BACKGROUND TO THE HOME COMPUTER MARKET

Computer terminals in the home have been forecasted for the past decade in almost all articles, reports and surveys dealing with the future effects of technology on American lifestyles. Justifications in terms of the changing environment of the family have included:

1) Growing desire for self-education
2) Increased leisure time
3) Increased educational level of the average consumer
4) Cost-and resource ineffectiveness of hand-delivered magazines and newspapers
5) Frustration with the increasing complexities of life
6) Growing concern over home security from burgulary and fire
7) Increased energy conservation awareness and
8) Desire for easy access to information data bases
9) Reduced effectiveness of public school systems

These trends are tied to distinct user needs as shown in Figure 1.1. THe TI Home Computer has been designed to meet these needs in the most cost-effective manner present technology allows.

Even though Home Computers can effectively address consumer needs, two questions are commonly asked concerning how the market will evolve:

1) When will the combination of cost, performance and ease-of-use for computer hardware reach a point that will activate purchase by the mass consumer market?
2) What companies will be best able to capitalize upon the satisfaction of these consumer needs?

With the development of the microcomputer, and its application to low-cost hobby computers, the cost of producing computer hardware to meaningfully address consumer needs has fallen below $1000. At $500 it will be less than 10% of the annual disposable income of the average American family. Just as the pocket calculator became a mass consumer market item when it fell below $150, personal computers will quickly reach a critical cost; the TI Market Research Survey determined that $300 is the critical price point, but this is affected by consumer awareness and education regarding computers. (See Figure 1.2 and 1.3) While an average consumer can easily understand the utility and operating technique for a calculator, he must undergo the frustration of training to realize the benefits of a home computer. For this reason, ease-of-use has been a primary criterion in the design of the TI Home Computer. Without this, and the capability to solve readily perceived consumer problems, home computer adoption by the average consumer could be suspended indefinitely.

The question of which companies are in the best position to capitalize upon personal computing has been addressed by at least four independent market studies in the last year. Typical of their assessment of key strengths that will be important are the following (from the Mitchell, Hutchins, Inc. Study):

- Semiconductor production
- Semiconductor technology
- Personal computation products
- Computer products
- Mass production in general
- Mechanical componentry
- Displays
- Advanced display technology
- Consumer product marketing
- Consumer product distribution
- Industrial distribution

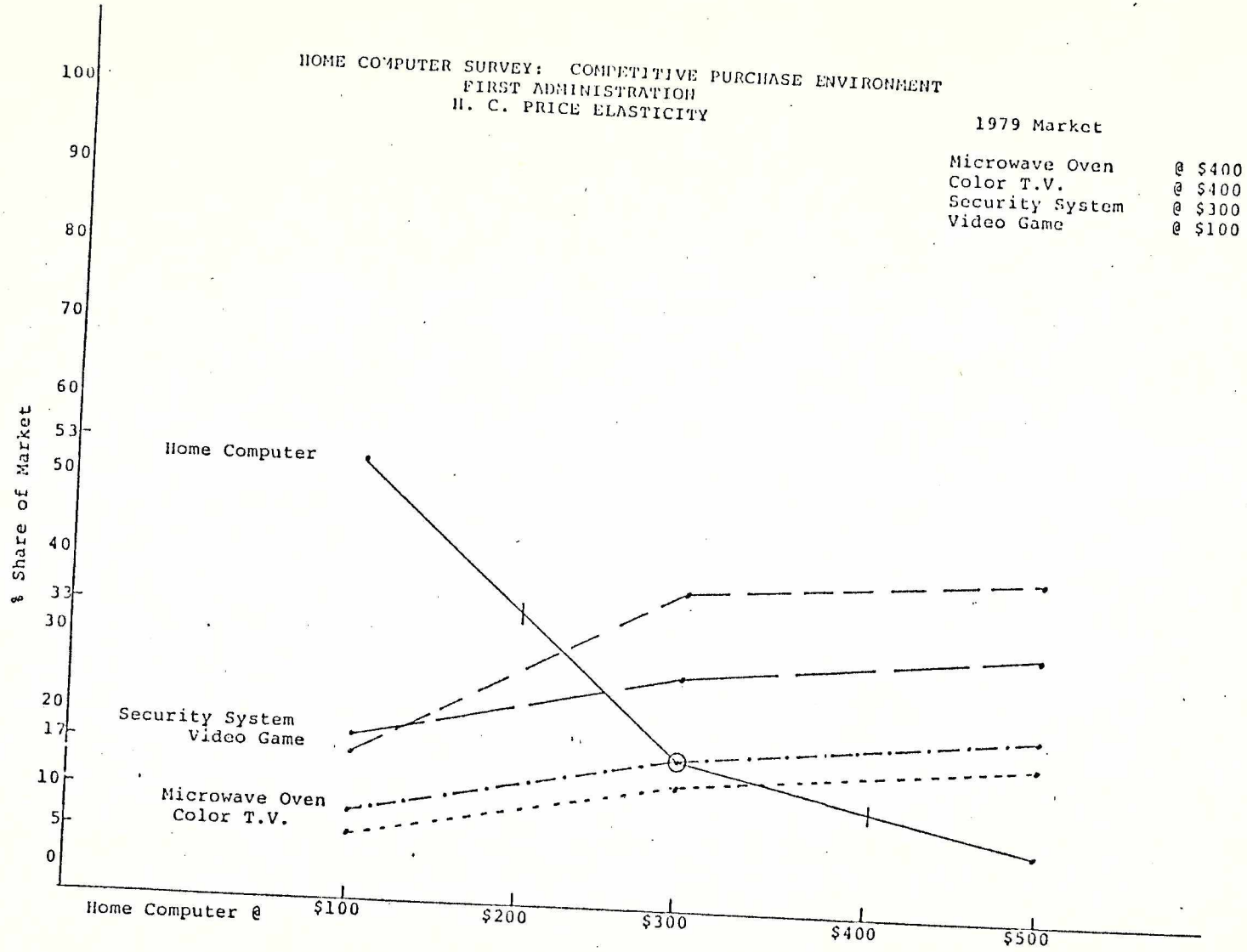
All of the studies that forecast key participants in the evolving home computer market have chosen TI as the most likely to succeed. This is not too surprising since there has probably never been a product more ideally suited to TI's existing stengths.

This White Paper demonstrates that maximum use has been made of these TI strengths in the design and implementation of the Home Computer. Contingency plans are also described to demonstrate that unanticipated problems and changes in the character of the market or competition will not prevent successful and profitable production and marketing of the TI Home Computer.

SOCIOLOGICAL TRENDS AND PRODUCT NEEDS

TREND	NEED	PRODUCT
• SELF-EDUCATION	• SELF-TEACHING IN THE HOME	• SOFTWARE-BASED PROGRAMMED LEARNING COURSES
• LEISURE TIME	• CHALLENGING/INTERESTING/ REWARDING ACTIVITIES	• INTERACTIVE SIMULATIONS AND SOPHISTICATED COMPUTER GAMES
• EDUCATIONAL LEVEL	• MORE SOPHISTICATED APPLIANCES; OPPORTUNITY TO LEARN TO PROGRAM COMPUTERS	• HOME COMPUTERS; COMPUTER PROGRAMMING INSTRUCTION
• INFORMATION EXPLOSION	• LOW-COST, RAPID ACCESS TO INFORMATION	• ELECTRONIC DATA BASES/ MAIL ACCESSIBLE FROM HOME COMPUTER MODEM
• COMPLEXITY OF LIFE	• FRUSTRATION-REDUCERS; ORGANIZING AIDS	• FINANCIAL PLANNING/TAX RECORDKEEPING, LIST-SORTING PROGRAMS THAT ARE SELF PROMPTING
• HOME SECURITY PROBLEMS	• REDUCED WORRY OVER SAFETY OF HOME, FAMILY, POSSESSIONS	• HOME COMPUTER MONITORED SECURITY SYSTEM

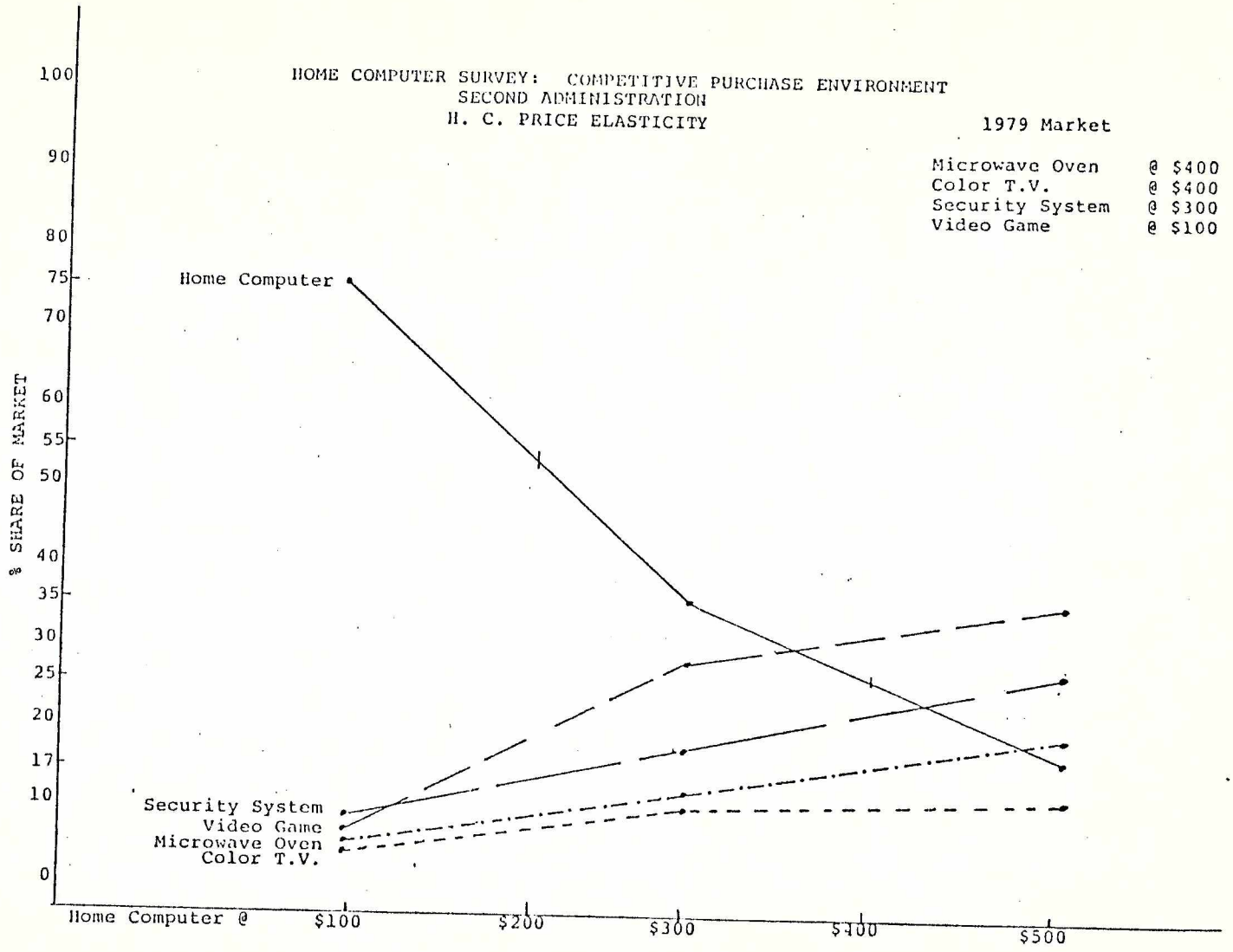
FIGURE 1.1



Implications:

- After some product knowledge a $300 price point appears competitive.
- For every $14.00 increase in price over $300, a 1% loss of market is experienced.
- For every $6.25 reduction in price below $300, a 1% gain in market is experienced.

FIGURE 1.2



Implications:

- Price is a sensitive issue.
- Twice as many people willing to pay $300 after education or,
- With low advertising we can lose 50% of the market.
- For every $10 increase in price over $300, a 1% loss of market is experienced.
- For every $20 decrease in price below $300, a 1% gain in market is experienced.

FIGURE 1.3

2.0 DESCRIPTION OF THE USER

2.1 MARKET SURVEY DATA SOURCES

As reported in the White Paper of May 6, a TI Home Computer survey of 504 respondents was conducted in Pittsburgh by an independent agency. This survey was supplemented by "The Gallup Study of Consumer Attitudes Toward and Interest in Owning Computers for the Home", the Mitchell, Hutchins Inc. Status Report on "Prospects for the Personal Computer", and the Vantage Research Study on "The Consumer Computer Market". Since May 1, 1978, a study has been issued by Creative Strategies International on "The Personal Computing Industry" which proivdes substantial quantitative data and an excellent competitive comparison. While differences exist in the results of the surveys, they uniformly affirm the existence of consumer market demand for home computers. They are also reasonably consistent in characterization of the user in early stages of market development.

2.2 USER TYPES

2.2.1 HOBBYISTS

Through 1977, the majority of personal computer sales were to hobbyists. This segment is characterized by its technical orientation, interest in tinkering, and attraction to peripheral devices. About 25,000 units were sold to this group in 1977 and about 40,000 will be sold in 1978. The hobbyist market will saturate at about 300,000 total units in 1982.

2.2.2 HOME PROGRAMMERS

Creative Strategies' Report separates the consumer market into programmers and consumers. Programmers have characteristics similar to those in the early stages of the first-wave buyer segment in the TI Survey. They have some knowledge of computers and either know how to program or want to learn. Scientists, engineers and technically-oriented small businessmen dominate this group of college-educated males, 40 years old and younger, with household incomes $15K to $35K. Their purchases of personal computers will exceed those of hobbyists by more than a factor of two in 1978 and will continue to constitute the largest segment through 1981.

2.2.3 CONSUMERS

Last to enter the personal computer market, but eventually forming the largest segment, is the consumer. Similar to programmers in income and education level, the consumer segment differs in its broader range of skilled professions and its reluctance to program the computer, leading to a strong dependence on available canned software.

This is the segment that will engage in software module purchases much as it now purchases stereo records and tapes or video game cartridges. Ease of use is the central focus of the consumer segment. Women will participate in purchases very little during the early 1980's but will gradually increase during the decade to a level near that of male consumers.

3.0 PRICING STRATEGY

3.1 TOTAL AVAILABLE MARKET

Results of the TI Home Computer Survey indicate a TAM over the next 17 years of between eight and forty million units. In 1978, actual personal computer sales will be approximtely 160KU. Sales of personal computers including peripherals and software will exceed $300 million in 1978. The SAM in 1979 will be between 250KU and 400KU, depending upon the amount invested in consumer education through advertising and promotion. Average retail price of personal computers sold in 1978 is about $800 for the basic systems. In 1979, the price will remain relatively constant but performance, and peripheral features and software availability will be upgraded.

3.2 PRICING MATRIX

Extremes of 1979 TAM were conservatively chosen from TI Survey data with 60KU at a $500 retail price and the lowest level of consumer education to 400KU at a $300 retail price and the highest level of consumer education (See Figure 3.1). Projecting TI penetration from 20% to 70% at the two extremes, a matrix is constructed which provides a variable profit map. The education axis of the matrix varies from a measured media advertising level of 2% of NSB to 10% of NSB. The matrix provides guidance on the combination of NUB, price and advertising expense to maximize organizational profit. Capacity limitations on first year chip production constrain the U.S. NUB to be 50KU. A conservative advertising level of 4% of NSB and present manufacturing cost estimates drive the price point to $400. Any change in forecasted MLO for the Home Computer will alter this choice. The $400 retail price should be considered tentative until initial chip yield information is available.

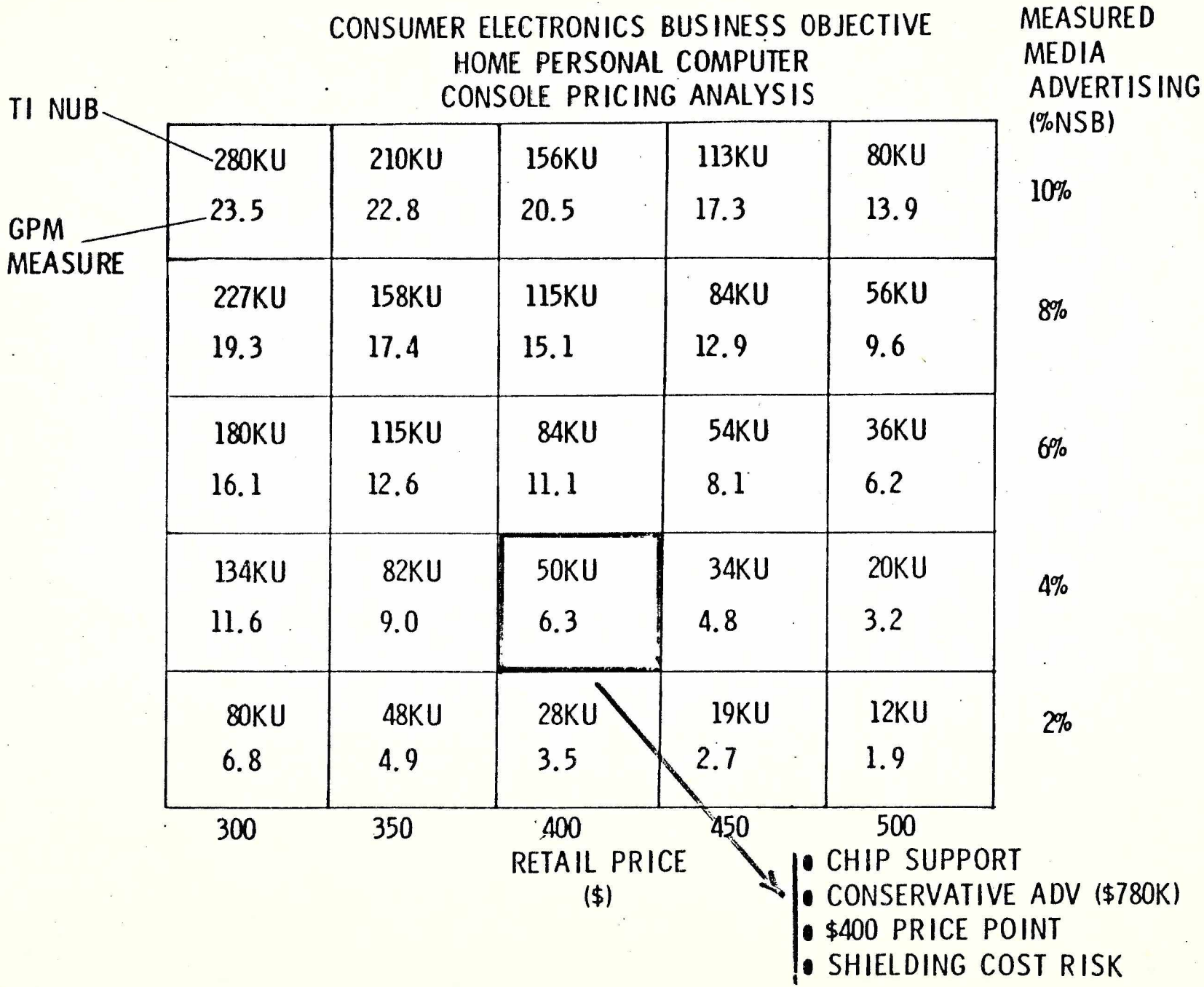


FIGURE 3.1

4.0 MERCHANDISING PLAN

A merchandising strategy has been established to support a test market in a few selected cities. Chicago, New York, and Los Angeles are the tentative selections. We will be able to evaluate in this test the advertising and sales promotion effectiveness, initial user profile and capabilities, a variety of service alternatives, and viable retail pricing. We will also be able to evaluate the effectivenes of the retail sales training program and point of purchase display.

4.1 PRESS RELATIONS PROGRAM

The press relations program involves introduction of a new concept to the public and takes maximum advantage of TI's entry into the home computer market with a moderately priced, easy-use computer having new and useful capabilities in home management, education, and entertainment. The impact of a good public relations campaign is significant in introducing a new concept. The impact is more positive if publicity is editorial in nature versus paid advertising. The present plan involves a press introduction seminar at the January Consumer Electronic Show with formal presentations on TI's Home Computer concept. This will be followed by a hands-on demonstration of the usefulness of the system. About 100 to 150 people will be invited from television, radio, the wire services, newspapers, business and technical press. We also plan some pre-briefings with key weekly magazines in the business, technical, and news areas to lock in special editorial treatment in long lead publications for appearance to coincide with the CES.

4.2 PRODUCT LITERATURE

A product brochure is currently in the design stage. This publication will be a 12 page, 4 color market description covering the console plus peripherals. In addition to the product brochure, there will be a retail flyer which will be a black and white slim line with basic description of capabilities to be used on the counter and/or as stuffers. A pocket card for the retail clerk is also in the planning stages. This card lists 20 top objections to buying a home computer now and key responses to those objections.

4.3 ADVERTISING

The present advertising development plan will be through a network of magazines. This will enable us to key into the trial and rollout cities by zip code. The ad will be a two page, four -color brochure and will appear in 3 issues. Newspaper advertisement is also being considered.

5.0 MARKET ENVIRONMENT

Consumers have become sensitized to the imminent availability of "personal computers". Most consumers have a higher perception of these machines' capabilities than can be delivered in the initial offerings. For this reason, we will not call our machine a computer. An activity to select an appropriate name is currently underway. By August 31, Tracey Locke will complete focus group studies to provide a choice among the 40 final names left after extensive elimination within TI.

Retailers are wary of personal computers for several reason. First, the Umtech Video Brain at $500 and the Wards' Cybervision at $400 have been failures due to their high price, non-programmability, poor canned software, and poorly executed merchandising. Second, the average retailer does not understand computers nor how to sell them and thus adopts a "wait and see" attitude. Nonetheless, a recent survey by Home Furnishings Daily revealed that the majority of retailers believed they would be selling personal or home computers before the end of 1979.

The key national accounts with whom we have discussed the machine are uniformly enthusiastic about our product approach which is driven by these leadership elements:

- High quality, human-engineered software
- Software in ROM media (not tape) for high speed, ease of use, and elimination of tape loading errors
- Low ROM cost per bit due to our leadership in PMOS production technology
- Low cost systems based on four -chip base set that provides full peripheral I/O
- Highly esteemed brand image
- High leverage peripherals
  - Speech synthesis - educational impact
  - MODEM - communications
  - ADD - low cost, high speed consumer mass memory

The present product offerings are results of two phenomena that have been in existence since early 1977, TV games and hobby computers. The TV games manufacturers discovered quickly that "programmability" (via canned cartridges) was key to extended console untility. They are now learning that a "touch" of computer programming is required (Bally and Magnavox). The hobby computer vendors have in general migrated upwards in price and function to serve the small business market after they began to saturate the build-it-yourself market.

The latest competitive products are summarized below. None has approached the combination of TI's leadership elements listed above.

5.1 HOBBY VENDOR ACTIVITY

5.1.1 RADIO SHACK

Now has a line of packaged systems from $599 to $4000, all based on TRS-80 mainframe. Will sell 75K systems in 1978 for $78M through 3500 U.S. Radio Shack outlets and another 500 in Europe. Both Shack and non-Shack tape cassette software packages are available. Most mainframes orders are now for the Level II BASIC at $695 with 4K RAM.

5.1.2 COMMODORE

Base Pet system at $795 includes black and white monitor and calculator-style 5/8" matrix keyboard. Will sell 25KU for $25M in 1978 through direct mail and selected mail order OEM's. Priced at $1200 in Europe. Tape-based software is specified and generated by third parties for cash or royalties.

5.1.3 HEATH

Sales will be limited to 8K units in 1978 for $14M due to delay in emphasis of assembled units. Virtually no merchandising or software. Little interest in understanding the consumer marketplace.

5.1.4 APPLE

Will sell 11KU for $20M based on $1395 mainframe (recently reduced to $1095) with tape-based vendor software packs announced. Aggressive distribution expansion includes electronic specialty stores as well as hobby stores. Tape, disk, phone, and control peripherals available. Most users modify their color TV's for video input or use monitors to exploit high resolution graphics capability.

5.1.5 EXIDY

Sorcerer at $895 will move 8KU in 1978 for $7M through hobby outlets. Unique cartridge-loaded BASIC language will be replaceable later with FORTRAN, extended BASIC, COBOL, APL, PASCAL, etc; an excellent strategy to capture the avid programmer. Application software is tape-based.

5.1.6 TOSHIBA

T-400 at about $900 is a beautiful, powerful machine, but appears to have been designed strictly for the hobbiest. Company is attempting private label marketing at this time. An entire line of personal computers from the T-100 to the T-1000 is planned for 1980.

5.1.7 COMPUCOLOR

Compucolor II at $1395 contains a color CRT due to experience of parent company (Intelligent Systems Corp.) in the color monitor and terminal business. Estimated 1978 billings of $10M on 6KU shipments. Sophisticated merchandising material based on superior system color graphics capabilities.

5.2 VIDEO GAME VENDOR ACTIVITY

All these units use the home color TV as their display.

5.2.1 BALLY

Home Library machine at $300 will sell 25K units in 1978. Unit has 20 key calculator keypad. "Bally BASIC" cassette software cartridge at $50 allows user to experiment with a minimal ability to write, edit, and execute BASIC code to satisfy his curiosity. Remainder of software consists of games, with 7 announced at this time. Computer attachment at $400 extra with MODEM and full size keyboard is expected to pass FCC in 4Q and will allow future peripheral attachments.

5.2.2 ATARI

Plans to ship 680K games in 1978 at $179 based on 5-chip set. Their minimal chip set will form the basis for a low priced computerin 1979 . Twenty sophisticated game software cartridges announced, nine in production.

5.2.3 UMTECH

Video Brain at $500 has sold very poorly despite intensive promotion at Macy's. Twenty-two software cartridges (ROM) announced. Lack of programmability in low cost unit denies consumer the ability to satisfy his curiosity and/or learn how to program. Family of products up to $1100 has been announced, all based on same mainframe and various mixtures of software and tape or phone peripherals. Minimal programmability is available in the $800 level option.

5.2.4 MAGNAVOX

Odyssey II at $129 has QWERTY non-travel keyboard. Has keyboard plus two joysticks, extremely sophisticated animated games, including "Introdution to Computer Programming" cartridge.

5.2.5 INTERACT

Model One expected to move 10KU in 1978 for $5M. Built-in tape cassettes and QWERTY non-travel keyboard. Twelve program tapes announced.

6.0 SOFTWARE STRATEGY AND PACKAGE DEFINITIONS

6.1 THE ROLE OF APPLICATIONS SOFTWARE IN THE HOME COMPUTER THRUST

Consumer interest in home computers is motiviated principally by utility . The TI survey indicates that the consumer's purchasing interest increases dramatically with his perception of usefulness. Appearance, ease of operation, and price are key factors that make possible a retail sale, but software is the driver.

Consumers have been found in home computer research and focus groups to be motivated by the desire to relieve stress in three areas: time, money, and social interaction. Our software is selected to address those issues. For example, social embarrassment is avoided for the beginner chess player by allowing him to develop his understanding of chess fundamentals without exposing his inexperience to his friends. Social involvement is heightened by supplying parent educational cooperation in the preschool and grammar packages.

Retailers also perceive software as the key hurdle to expanding the home computer market. Ward's, Penney's and Sears all feel that current consumer software offerings are weak. While retailers generally agree with TI's software topic selections, they are waiting for TI to show them what quality software can be. Their only strong feeling is that games are currently being overplayed in the marketplace.

TI's initial software offering sets a standard for potential software contributors. Members of the educational and training communities will evaluate TI as a potential software publisher based on demonstrated capabilities and software understanding. TI procedures and techniques will set standards for unsolicited submissions from the public. Finally, our ability to recruit quality, endorsement-caliber consultants will be impacted by their opinion of TI professionalism.

6.2 COMPETITIVE APPLICATIONS SOFTWARE

Initial performance of consumer computer manufacturers has set a poor standard for the industry. Radio Shack rushed its introduction of hardware to meet the Commodore PET announcement. The result was an offering of trivial, inaccurate software. The second round offering from Radio Shack showed considerably more sophistication but not a significant improvement in human engineering - the software was often too difficult to use and did not fulfill the stated objective. Radio Shack has begun to court the business market with its equipment, even arranging for equipment leasing on the west coast: $135.95/month for a system with 32K RAM, a printer, two disks, a monitor, a cassette recorder and marginally useful business software packages).

PET offered no software until March 1978. Prior to that even system documentation was difficult to obtain. Recently software availability has improved through their use of outside submissions.

As it became clear that manufacturers were not on top of the software market, sole proprietorship software houses appeared. Appendix C is a listing of available software compiled by an individual on the west coast. The swelling of grass roots software development underscores its importance to the computer owner.

6.3 TI'S SOFTWARE STRATEGY

TI's Home Computer software strategy is to supply a broad selection of truly useful, engaging, long-lived software to the TI computer owner. There are three key elements to this strategy:

1) Develop carefully planned, efficiently coded, and well tested software within the product department.

2) Encourage and assist potential software authors who are expert in various areas of consumer interest to use as their publication medium and TI computers to "play" the GROMs. This leverage will not significantly impact software availability until ten months after product introduction.

3) Screen and prepare for redistribution programs submitted by the public in TI BASIC. This leverage will be felt approximately four months after introduction time.

6.3.1 TI DEVELOPED SOFTWARE

TI is developing Home Computer application software in-house for the following reasons:

1) Quality software is integral to market introduction and no other mechanism of development can guarantee availability on schedule.

2) Sale of software represents a significant portion of the product line GPM.

3) TI can further develop its professional understanding of the home computer software market and business only by participating in the forefront of the industry's growth.

4) The "authorship" and outside submission programs described above require TI to break the ground, develop procedures, demonstrate the profit potential, and offer experienced development guidance to contributors unfamiliar with TI equipment.

The in-house development effort functionally begins with software topic selection followed by specification and programming. The clear guideline from TI surveys, retailer surveys and comments, industry reports, focus groups and other sources is that home management and education are the topics of highest expressed interest. Accordingly, six out of ten of our initial packages are targeted at these needs.

Each of the initial software product concepts was presented in a video tape based consumer survey. From the rank ordered list, topics were chosen that could be well developed on the basic machine to be offered at market introduction. These topics were subsequently reviewed with selected major retailers.

The amount of attention given to specification of a consumer program makes the difference between software that is trivial or useful, short or long lived, straightforward or complicated, erroneous or accurate, boring or fun, etc.

Considerations made during the specification phase are these:

- User Requirements
  - Users perceived needs at time of purchase
  - Perceived needs after experience
  - Features that attract the user
  - Limitations that may repel the user
  - Required knowledge, data, and skills
- Initial Function Selection
  - Which user needs are to be addressed
  - How to involve the user incrementally (rather than requiring 100% up front commitment)
  - Scope and sequence of functions
  - Identification of constants and variables
  - Flexibility to user variations
- First Cut Specification and Initial Review
  - Functional flow chart
  - Preliminary screens
  - Typical data and formulae to be gathered
  - Data storage and retrieval guidelines
  - What expert consultant help is required?
- Technical Feasibility Analysis
  - Does the RAM available support the functions?
  - How much ROM space is required?
  - How will data storage be handled?
  - Are system capabilities being utilized?
- Bench Testing
  - Are typical potential users satisfied with program features?
  - Does it meet their expectations?
  - Are users motivated, bored, or confused?
  - What data or skills are required?

- 0 Specification Revision, Formalization, and Review
  - Incorporate technical and bench testing discoveries
  - Complete all sections of specification format guidelines
  - Submit to legal for evaluation
- 0 Coordination With Programmer
  - Resolve unsettled questions quickly
  - Formalize any mid-course specification change requests
  - Outline owners manual

Programming of the Home Computer software is distinguished by the flexibility of programming at assembly language level and by the permanence and expense of the ROM mask tooling. These two features call for continued support of product planners through the programming and final testing of software. It is up to the product planner to determine if the software performs as expected or whether it requires modification prior to first pass ROM production.

Software descriptions are listed below for each of the ten applications packages (or GROMS) targeted for introduction. They are listed in the order of expressed interest on the TI poll and are referred to by in-house (not final market) names.

6.3.2 INTRODUCTORY SOFTWARE DESCRIPTIONS

Household Finance is intended for the household that desires assistance with one or more of the following:

- Identification of expenditures by category and month
- Budgeting of expenditures by category and month
- Projection of cash position (incomes less projected expenses)
- Outstanding check tracking and reconciliation*
- Cleared check reference and storage*

The Household Finance GROM adds a major increment of utility to other known personal finance systems in that it requries only one tape and provides more information than simply a list of outstanding checks.

Home Financial Decisions offers quick answers to the most common financial decisions of a typical American family. It is characterized by "prompted" questions and a minimum of data input to obtain meaningful guidance in financial decisions. Should I lease or buy a car? Is my situation better suited to whole life or term insurance? What percent of my house payment will be tax deductible in future years? By asking a few simple questions, the TI Home Computer can answer these, and a host of other important questions quickly and easily.

* AVAILABLE ONLY ON THE EXPANDED MEMORY VERSION

The Grammar and Reading GROM is being offered for drill and practice on parts of speech and sentence structure for grade school children. The material is based on a series of seven activities and classroom tested by an experienced, grade school instructor. These activities are being molded into format and graphic content appropriate for the Home Computer with the assistance of consultants trained in Childrens' Television Workshop working with Sesame Street, Mr. Rogers, etc.

The Health and Nutrition GROMs (two different packages) meet the consumers expressed desire to specifically identify nutritional, weight and exercise requirements of his sex, height, build, and age group. The program then assists the user in developing personal exercise and diet plans if desired. The programs offer the option of storing performance-against-plan information for automatic plotting o weight or exercise progress. This feedback can be the key to successful plan maintenance. Finally, the programs allow the user access to detailed nutrition and exercise tables used by other portions of the program.

Chess Master is being developed with the assistance of International Grand Master and recognized computer chess authority David Levy. The GROM provides an ever ready opponent and instructor for beginner through advanced players. With variable styles and levels of play, the Chess Master eliminates the widespread problem of not having an evenly matched opponent. The GROM also eliminates the potential embarrassment that a novice player can have playing against more experienced human opponents. The Chess Master offers simultaneous game play and problem/exercise modes in addition to single player games. The simultaneous feature is keyed to chess club purchasers. Problems and exercises allow practice with particular game portions and are popular with avid players. Ninety-five percent of all regular chess players will lose to the Chess Master at its most difficult level of play.

The Preschool Package integrates letter number and shape recognition with keyboard learning experiences. Developed with the assistance of Joslin Gunnar of Sesame Street Magazine, the package is designed to provide reinforcement to lessons taught by parents, TV, and pre-school classes. It is a point of entry for both the parent and child into the computer world with natural progression through these integrated concepts:

- Number recognition, sequence, and keyboard location
- Counting skills
- Shape matching and menu selection
- Shape discrimination and counting from a mixed field
- Incongruity identificaiton
- Letter recognition and keyboard location
- Letter/word association (A is for Apple)
- Strings of letters making words and the "ENTER" function
- Relational concept (arrows) and the "SHIFT" key The

Football GROM is a simulation based on known football play probabilities. The key user appeal of this GROM is in real time representation of play action, strategic selection of plays, and realism. The computer brings rapid statistical evaluation of offensive against defensive play and vivid graphic representation of outcomes, neither of which have been available before in the programmable game market. Players select plays from offensive and defensive play lists simultaneously on the TV screen. Secrecy of selection is insured if each player screens his use of the advance and select/advance keys. At the ball snap, players are blocked, make or break tackles, complete or drop passes, etc. all in a fast smooth flow of action. The outcome of each permutation of offensive and defensive call is based on the statistical distribution of real world games or losses. For example the probability of a long gain from a running play against a "prevent" defense is not zero but is very low.

Results of the TI Market Survey and other independent analyses indicate that, particularly among first wave buyers, there is a strong desire to learn how to program and use computers. The market is distinct from, and much larger than, the hobby computer segment which is characterized more by hardware enthusiasts who like to play with and modify their computers. THE BASIC TUTOR will provide programmed instruction in how to program the home computer in the BASIC language. Users of this GROM will solve sample problems as they learn new BASIC instructions and can overcome many of the frustrations of learning to program with only a manual for guidance. Successful graduates will have the option of purchasing the TI SR-62 or SR-70 products, programmable in supersets of the Home Computer BASIC.

Investment Analysis focuses on types of investments that benefit from sophisticated mathematical analyses. Put and call options, warrants, covertible bonds and many other investment vehicles can be analyzed for yield, expected return, theoretical value and other parameters. Individual investors are increasing their participation in this type of investment and depending upon newsletters and magazines to perform the kind of analyses that a home computer can do in real time situations.

Finally, a DEMOGROM will be available to both retailers to assist the sale, and users, to show off the capabilites of their home computers after purchase. The DEMOGROM makes maximum use of color graphics and sound to attract attention in the retail store environment. It allows incremental user involvement using excerpts from other GROMs to show a potential customer the useful benefits of the system. Assistance in this GROM was obtained from Tracey Locke to insure that it will quickly convince a potential buyer that he can use a home computer and that the Home Compuer will perform useful functions that quickly justify its costs.

6.4 AUTHORSHIP PROGRAM

In conjunction with the Corporate Engineering Center the Personal Computer Division is developing a key source of applications software. TI will make available to recognized authorities and institutions, in several of topic areas, software development equipment and training. These ouside authors will either develop software for subsequent sale or license to TI or, in some cases, for sale through their own channels of distribuiton.

There are several key reasons for the prompt development of the authorship program:

- Consumer demand for quality software is expected to outstrip the internal generation capabilities of any one firm.
- Topic expertise and related consumer confidence uniquely position certain outside firms for development and distribution of software (Example, Berlitz for foreign languages)
- Adoption of TI Hardware systems as their software delivery vehicle by a variety of well recognized authorities cements TI as Home Computer leader.
- Outside authors, sure of their market and software product, can underwrite an extremely high level of programming investment.

Work is already under way at CEC to establish a pilot program of outside authorship for the Home Computer. Experience with this program will be essential to development of the professional approach requried in dealing with prestigous authorities in a variety of fields.

6.4 LONG-TERM STRATEGY

Results of surveys have strongly influenced initial software authorings. These introductory packages demonstrate a wide variety of applications to potential customers and emphasize TI's intent to support its home computer with high quality useful software. With the exception of the Chess Master and Investment Analysis packages, all of the introductory software has very broad appeal. As a result, most of the packages do not individually provide sufficient justifications of a home computer by the average family. Viewed together, however, they show a wide variety of potential uses that will justify purchase of a home computer.

With this broad base of packages in place, it is now possible to increase the emphasis on packages of more restricted applicability. Chosen properly, packages that are designed for smaller audiences can address more critical needs. A single package can be useful enough to justify the cost of the entire system. Although broad-inerest packages will

continue to be introduced during 1979, more than half of the new introductions will be designed to individually make purchase of a home computer, or a specific peripheral accessory, a near necessity for a specific target market.

Chess Master is a good example of "software-pull" of home computer sales. There are over 20 million chess players, 50,000 of whom are members of the U.S. Chess Federation and 160,000 of whom belong to the German Chess Federation. Chess Challenger, a microprocessor based chess game, has been an outstanding success despite its very poor skill level and $300 retail price. This is an example of the increased willingness to buy systems in order to use a specific software package when the package addreses a critical need of a smaller market segment.

Investment Analysis falls in the same category. Only 600,000 Americans actively trade in the investment vehicles analyzed in this package. For this market segment, however, use of analytical techniques is a necessity and the cost of a home computer is small compared to the potential dollar risk of not having one.

Very small market segments will be addressed by independent third parties selling their programs on tape cassette or paying TI to produce exclusive GROM module packages which they retail themselves.

In 1979 many of the TI generated software module introductions will drive the sale of peripherals, as well as home computer systems. The speech module in 1Q79 takes advantage of electronic speech synthesis and gives the purchaser of the software module plus speech peripheral the benefit of spoken messages from his computer. Emphasis in the first package is on pre-school education, so that a child who cannot read the printed screens can follow verbal instructions.

Software support for the MODEM/DAA peripheral is probably the most exciting of all applications. Once a user has this peripheral, he gains access to existing information data bases and communication links that will without question make home computers a necessity in every home. There are already hundreds of phone numbers available for independent computers to talk to without charge. Instantaneous stock and commodity price quotations are available for a small charge and a phone call. When the ADD disc is introduced, large amounts of this type of data can be recorded in a short phone call and then software modules take over, analyzing the data in light of the user's investment portfolio. Doing library research is also greatly enhanced when information data bases are no farther away than our home terminal. Finally, in the middle of night, your home computer could easily be programmed to send a message to any other home computer owner for the one-minute 19 cent rate, eliminating the need for costly telegrams or the unreliabiity and security risk of first-class mail.

T.I. HOME COMPUTER SURVEY
HARDWARE/SOFTWARE RELATIONSHIPS

- Consumers who were not at all willing to purchase a home computer preferred the same software packages as consumers who were anxious to purchase a home computer.

  Two exceptions: Willing to purchase people liked Investment Planning and Math Tutor more than non-buyers.

- Willingness to purchase software was directly related to willingness to purchase a home computer. Buyers prefer any software about twice as much as those people who were not willing to purchase a home computer.

IMPLICATIONS:

- Lack of interest in software is due to lack of interest in home computer and vice versa.
- In general, price of software critical to home computer purchase - most want software but most will not pay more than $20 - $30.

FIGURE 6.1

Gallup H. C. Survey:
Software Package Preferences

Wide Appeal		Moderate Appeal		Narrow Appeal	
Alarm system	84%*	Pantry Inventory	55%	Family games	45%
Educational (adult)	75%	Appointment Cal.	54%	Calorie calculator	42%
Energy Conserv.	74%	Mailing lists	53%	Videogames (action)	37%
Ref. Auto maint.	73%	Kitchen appliance control	51%	Sports statistics	32%
Checkbook	67%			Recipe Inventory	35%
Ref. Sm. Appliance repair	67%				
Math tutor	65%				

* Based on respondents expressing general concept acceptance (26% of sample)

FIGURE 6.2

T.I. HOME COMPUTER SURVEY
SOFTWARE PACKAGE INTEREST

PACKAGES WITH BROAD INTEREST	
TAX & FINANCIAL	68% *
HOME MANAGEMENT	62-64%
INVESTMENT PLANNING	52%
MATH TUTOR	43%
GRAMMAR AND READING	40%
PERSONAL HEALTH	38%
MEAL AND DIET PLANNING	38%
BUSINESS SIMULATION	37%
PERSONAL CALENDAR	28%
PINBALL	27%
CHESS	24%
ENERGY PACKAGE	24%
WALL STREET	17%

PACKAGES WITH NARROW INTEREST	
MUSIC TUTOR	16%
FOOTBALL	15%
BLACK JACK	14%
PRE-SCHOOL COLORS/SHAPES	13%
SPACE WAR	9%
ROAD RACE	6%
ART DOODLE DAZZLE	5%
BACKGAMMON	2%

* % of those very willing to purchase a home computer

IMPLICATIONS:

- Personal and Home management) Education) Entertainment
- Concern for youth users is very low
- Provide tangible value to household versus entertainment

FIGURE 6.3

7.0 SYSTEM DEFINITION AND PERIPHERAL STRATEGY

7.1 SYSTEM DEFINITION

Figures 7.1 through 7.5 show the TI Home Computer in various configurations with and without the handheld units and receiver. Styling has been a principal emphasis in the design of the Home Computer because the unit must be usable in any room of the house. With present styling, the TI Home Computer will be appropriate next to an expensive stereo system in a tastefully decorated living room. Clutter caused by wires on most programmble video games and hobby computers is avoided with the IR link on the handheld units and modular styling for each of the peripheral accessories.

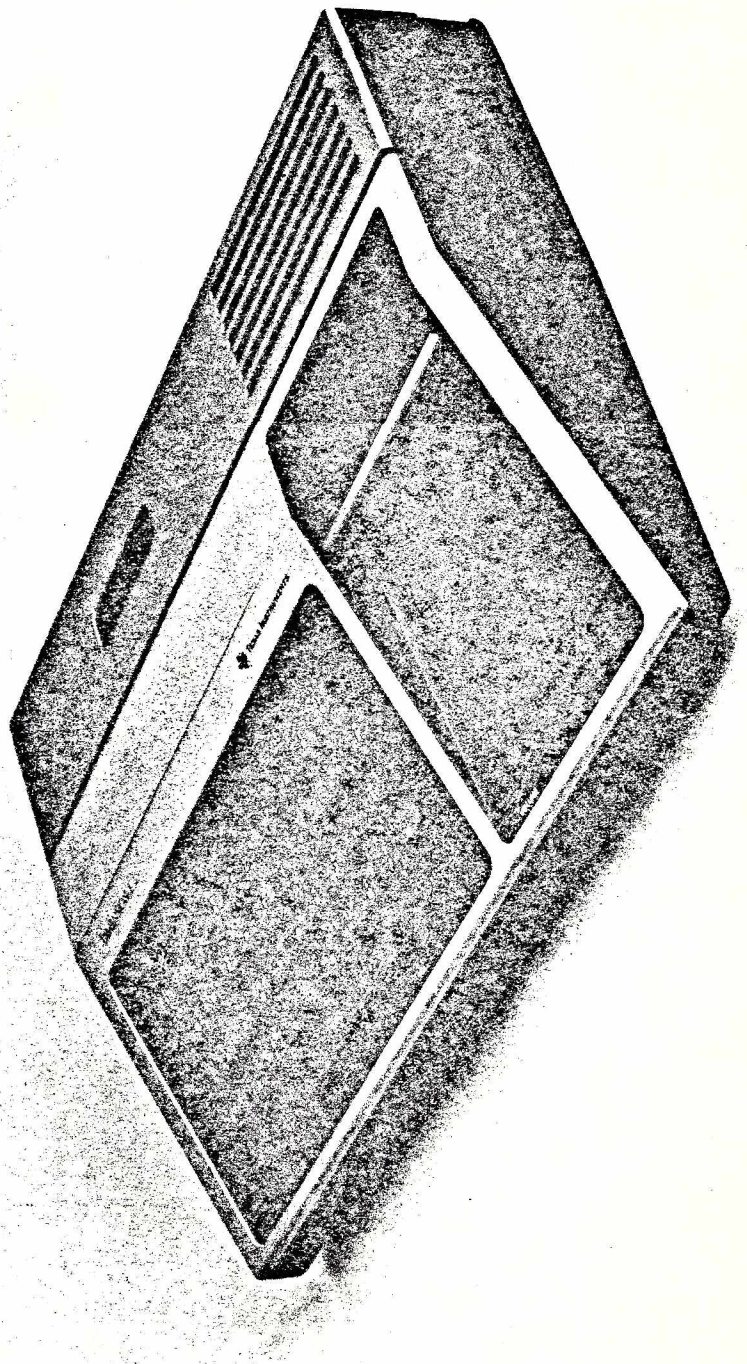
Connection to any standard television is made by clipping leads to the antenna inputs. Either Channel 3 or 4 can be used, depending upon which one is available in a particular local area (100% of the locations in the U.S. have one of these two channels available). Sound emanates from the television speaker and high resolution color graphics appear on the screen. Software modules slide easily into the slot on the front right side of the console, as seen in the figure. The keyboard is similar to a standard typewriter with forty full-travel keys to provide a high-quality professional feel.

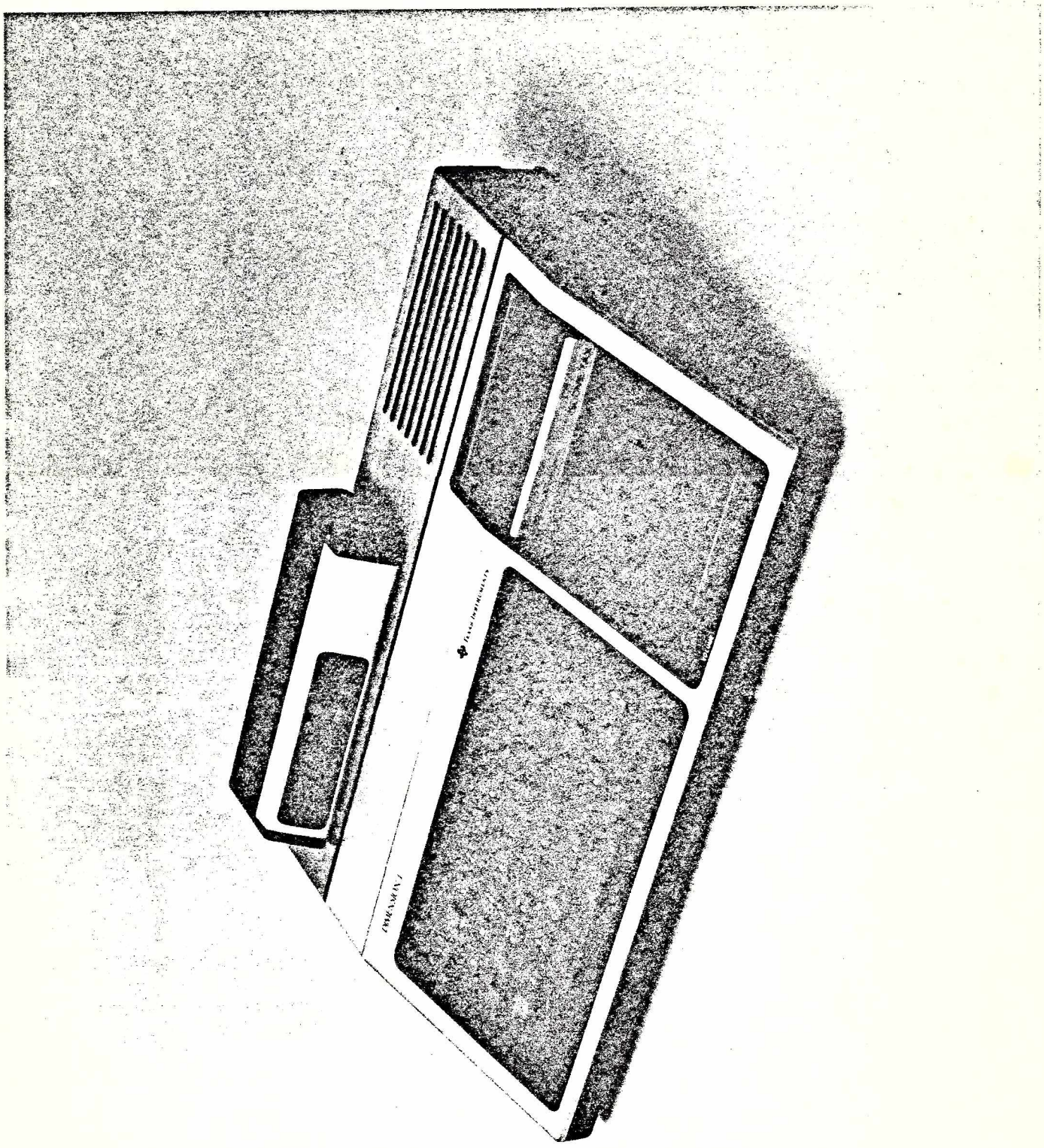
When turned on, and a software module inserted, the Home Computer displays an introductory screen that identifies the product and invites the user to press any key to begin. To relieve worry about screen burn-in, the Home Computer changes screen displays every 30 seconds if no key input is made for five minutes. An abbreviated system specification is included in Appendix A to provide further detail.

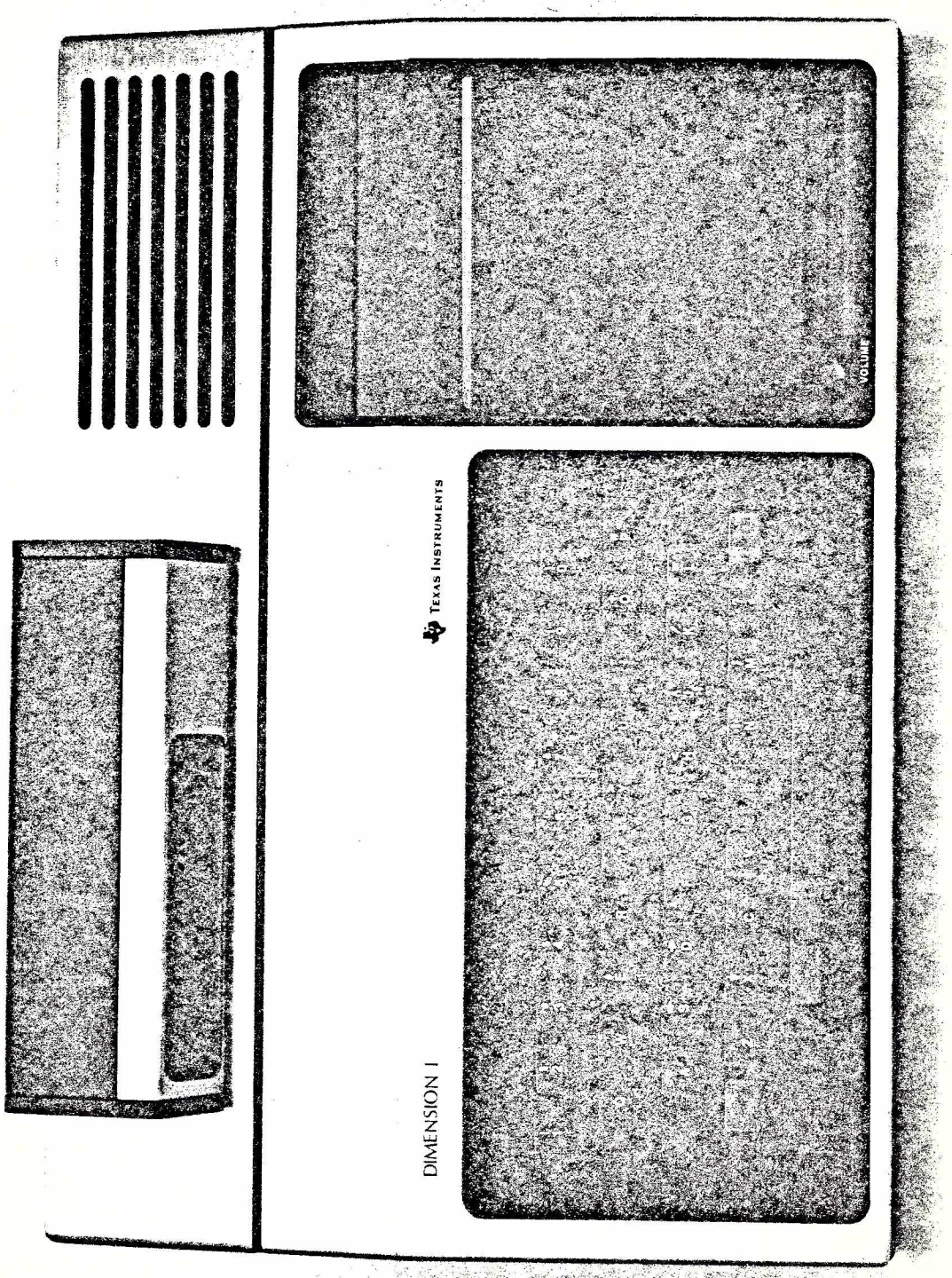
7.2 PLANNED PERIPHERAL ACCESSORIES

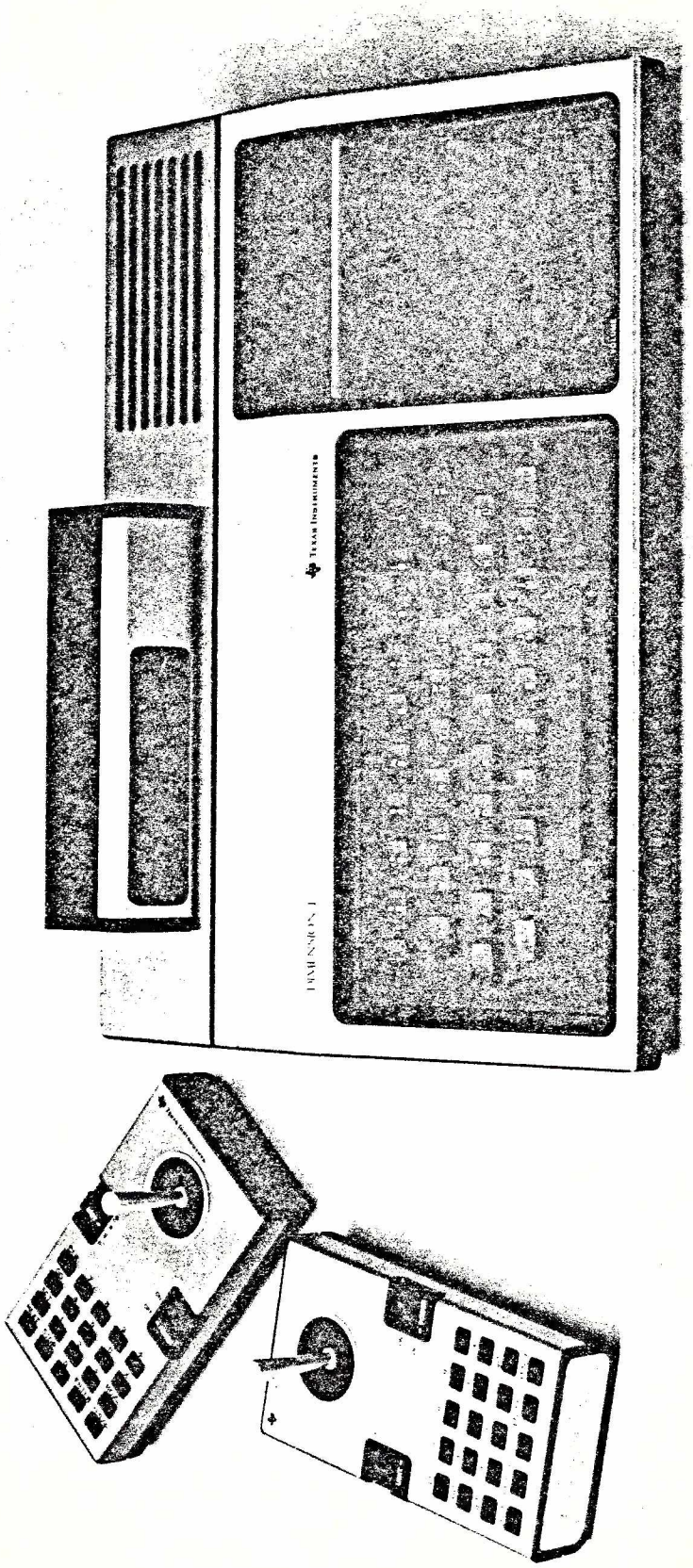
Entry products are the mainframe or console, remote handheld units (HHU) that communicate with a receiver on the mainframe over an infra red link, a manual cassette for non-volatile storage of data and/or programs, and 4Kx8 or 16Kx8 RAM expansions for the user who plans to do considerable programming. Other peripherals planned for later introduction include:

- Synthetic Speech Module based on Speak 'n Spell technology
- Software Module Library with capacity for eight software modules that can be selected under program control
- Peripheral Interface Expansion chassis for the customer who wants to connect more than four peripherals to the console
- Electronic Cassette unit that can be operated under software control. Two cassette units can be connected to the console to provide mass storage.









- ADD Disk unit to provide fast mass storage for applications requiring searches, etc.
- MODEM and DAA to provide, access to data base telephone communications between home computers write letters, etc.
- Security/control system for security applications including fire, forced entry, etc. and control functions for lights, appliances, alarms etc.
- Color monitor for the customer who wants better quality color and/or does not want to use a home TV set
- Typewriter peripheral for student text editing, typing instruction, etc.
- Checkwriter peripheral that can be used to automatically print checks required by the customer.

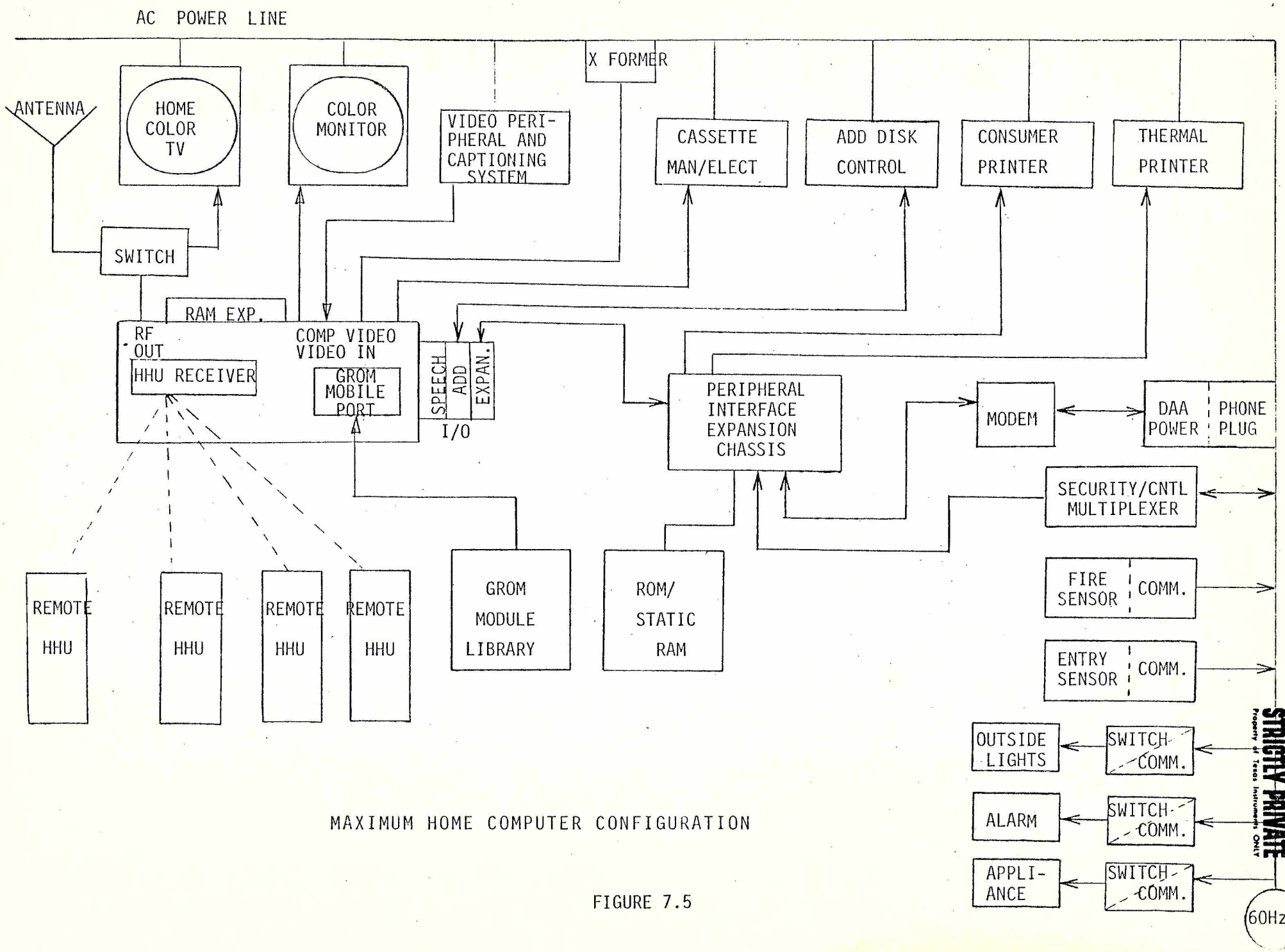
It is crucial that a wide range of peripherals be available. The range of peripherals is vital to the ability to configure a system that is really useful and meets the needs of each customer.

Figure 7.6 summarizes the planned peripheral accessory options. Design of the hand-held transmitters/receiver, the 4Kx8 or 16x8 RAM expansions, and the tape cassette (manufactured by Panasonic as TI private label) is essentially complete. Figure 7.2 shows introduction dates and retail prices for each peripheral accessory. Software modules are planned for simultaneous introduction with each peripheral to maximize user benefit.

Plans for the Home Security unit are described in Section 8.0. The following section contains a brief description of capabilities and status of other peripheral accessories. Much of the required design effort thus far has been expended to insure compatibility of the TI Home Computer console with future peripherals that are not yet designed. To do this, it was necessary to specify communcations interfaces and "worst-case" timing requirements for each peripheral. As a result the TI Home Computer has become a flexible mainframe computer. It is anticipated that third parties will capitalize on this flexibilty to introduce their own specialized peripherals, thus generating additional sales of TI Home Computers and furthering the move toward industry standardization.

7.3 HANDHELD UNITS

Figures 7.7 and 7.8 show the handheld units that are available as an optional accessory for a tentative $150 suggested retail price. The basic accessory includes the receiver, which plugs into the top of the console, and two handheld units with positioning cursor to move objects on the screen and a 5x4 keyboard to make entries. Up to four handheld untis may be used simultaneously. An automatic power-down feature guarantees 25 hours of actual operation



MAXIMUM HOME COMPUTER CONFIGURATION

FIGURE 7.5

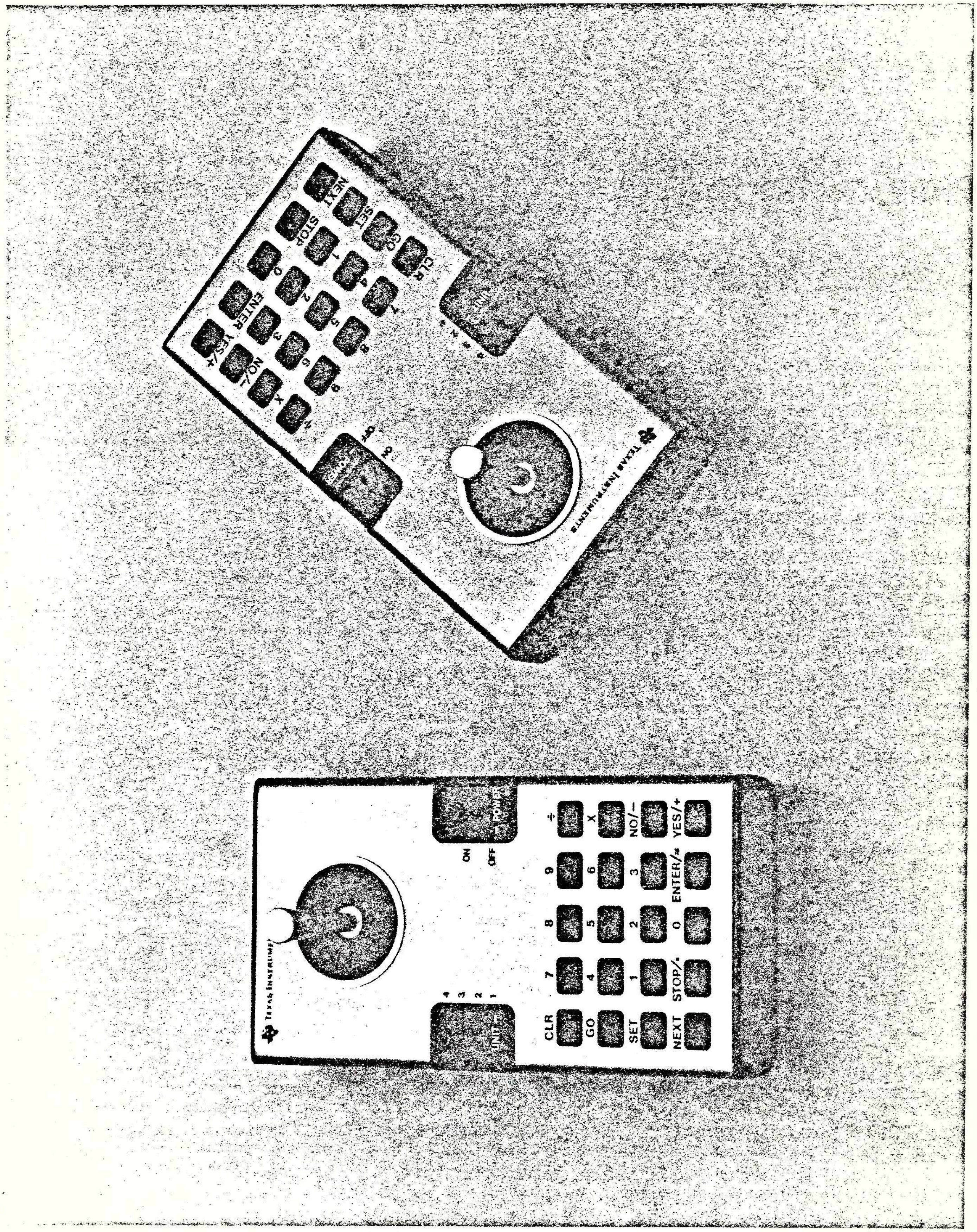
HOME PERSONAL COMPUTER

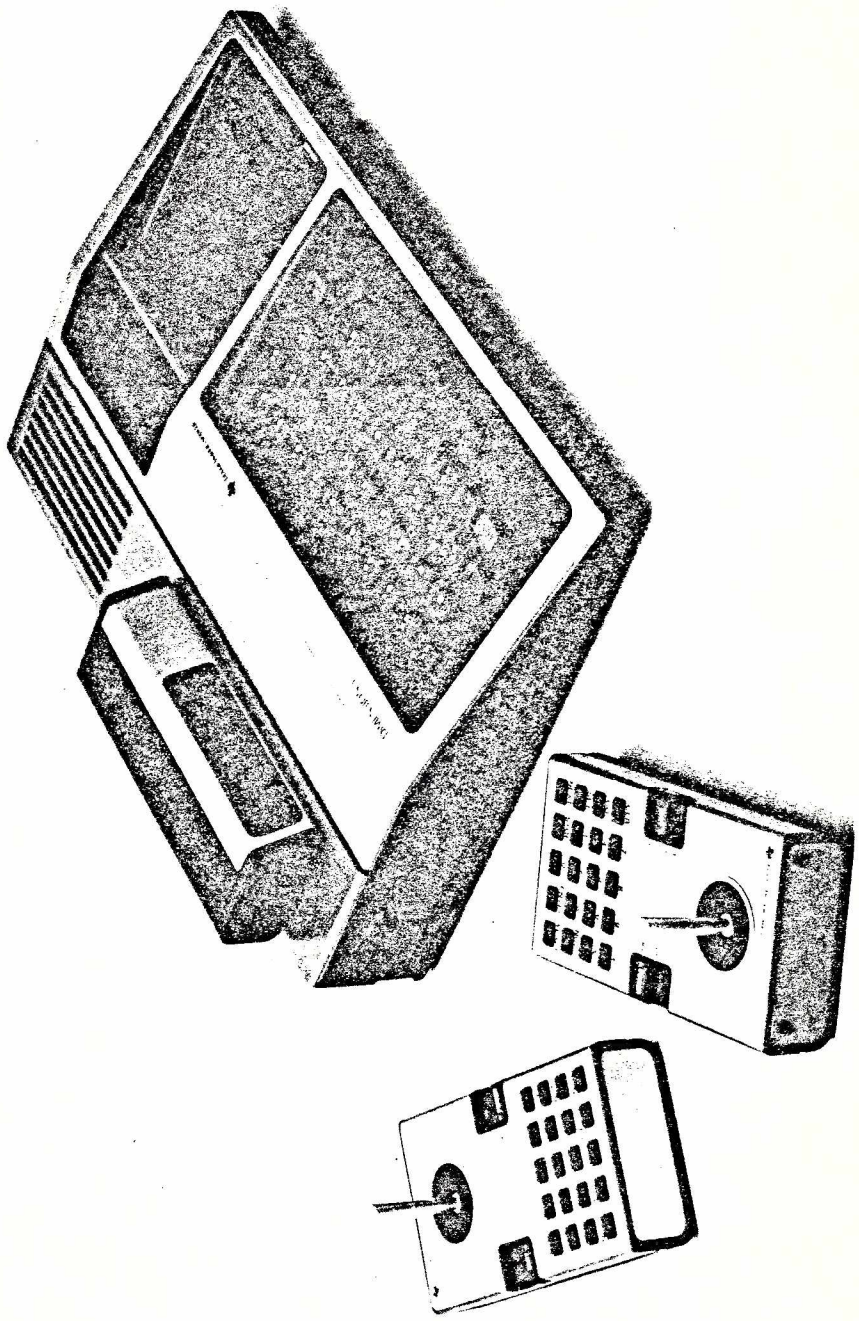
PRODUCT LINE PRICE STRUCTURE

	1979				1980				1981
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q
MAINFRAME	400				300				
SOFTWARE									
(NO OF MODULES)	10	5	5	8	8	8	8	8	8
REMOTE UNIT	150			80					
TAPE CASSETTE	60				40				
RAM EXPANSION - 4K	70			40					
- 16K		200			80				
- 64K						150			80
SYNTHETIC SPEECH		75			50				
TELEPHONE HOOKUP			180			90			
THERMAL PRINTER			230				150		
ADD DISK			425			200			
SECURITY									
(CONTROL UNIT)				300			150		
CONSUMER PRINTER						200		100	
CHECK WRITER						150		75	

FIGURE 7.6

T I C L A S S I F I E D
STRICTLY PRIVATE
Property of Texas Instruments ONLY





with a 9V battery.

The units can be used up to 20 feet from the TV. Any two units can be placed together in an optional cradle with overlay to provide a complete remote keyboard, analageous to the one on the console.

7.4 CASSETTE TAPE UNIT

To provide mass non-volatile memory data or program storge, a magnetic tape cassette will be offered for a $60 suggested retail price at product introduction. The unit chosen is manufactured by Panasonic and has a Texas Instruments private label. Sophisticated encoding techniques have been used to avoid the high error-rate problems found with the Radio Shack TRS-80. A 1200 baud data rate can be handled at 10^{6} errors/bit. During 4Q 1979, an electronic cassette will be introduceed that allows program controlled access of data, recording and start/stop.

7.5 RAM EXPANSIONS

Using the standard TMS 4027 and TMS 4116 4K and 16K RAMs, memory expansion modules have been designed for serious programmers or users of planned modules with increased capability. The expansion modules are inserted into the console circuit board by removing a cover on the back of the console. Tentatively priced at $50 and $200 respectively, these expansions add program storage capability up to that required in home-based business applications.

7.6 SYNTHETIC SPEECH/LANGUAGE SYSTEM

A Home Computer peripheral module will be announced in 1Q79 using TI's low-cost P-channel MOS electronic speech synthesis technology. This will be a unique capabiliyt, unavailable on other home computers at any price. Foreign language instruction and translation GROM modules are planned for introduction in 1979 to enhance the utility of speech capability. By building a basic vocabulary into the module, home progammers will be able to place verbal messages and results in their programs and non-programming GROM module users will benefit from the increased ease of use of program. The basic unit contains a 600 word vocabulary and plugs into the I/O port on the right side of the console.

7.7 THERMAL PRINTER

Many financial calculations benefit substantially from hard-copy output. A 32-column thermal printer has been designed using two 16 character thermal print heads. The 32 columns match the TV screen format and can be printed simultaneously with display of complementary data. Program modules that benefit from printing have been programmed with printing instructions that are ignored unless the optional printer accessory is connected. Introduction of the thermal

printer is planned for 2Q79 at a suggested retail price of $300.

7.8 TELEPHONE MODEM/DAA

Using TI's CCD MODEM chip, design of a MODEM/DAA interface module has begun. Introduction is planned for 3Q79 at a $300 retail price. Initially the unit will be used under GROM module or user-programmed control to automatically call phone number and transmit or receive data and messages.

In 1980, a program module will be offered with autodialing and phone answering/recording capability. The MODEM/DAA will be the single most important peripheral to make the Home Computer a required household appliance. Initial discussions have already begun with owners of data bases to establish access procedures. In the longer term, shopping by computer, electronic funds transfer, magazine/newspaper transmission and electronic mail are all possible extensions with no additional hardware development.

7.9 ELECTRONIC TYPEWRITER

By designing the Home Computer I/O with flexibility, it has become possible to provide an interface to many of the standard electric typewriters on the market. Private labeling of one of these systems is planned in 4Q79, along with software to provide text editing functions. Success of TI's Consumer Impact Printer program will provide a $100 printer peripheral by late 1980.

7.10 OTHER PERIPHERALS

The above units, along with home security control, have been selected for highest priority because they satisfy critical user needs and will stimulate additional console and software sales. The important factor to consider at this stage of devlopment is compatibility of the TI Home Computer console with peripheral devices of ever-increasing sophistication to allow generation of future profitable peripheral products by TI and third parties. This compatibility that is now designed into the Home Computer.

8.0 SECURITY SYSTEM DEFINITION

A home security (HS) system effectively provides alarms for fire, intrusion, and any type of home emergency situation such as personal injury. Market research has shown that a product which offers some degree of home security has an intrinsically high consumer perceived value. Also, it is important to note that we are primarily concerned with existing homes rather than new built-for-security homes.

8.1 THE HOME SECURITY ENVIRONMENT

8.1.1 PRIMARY CONCERNS OF DWELLERS

The HS environment is characterized primarily by the security concerns of dwellers. Through a market survey and several marketing focus groups, the following concerns have been established:

1. Fear of confronting an intruder when returning home or aroused from sleep
2. Concern with losing family mementos in a fire
3. Concern that the alarm gets to the right people
4. Afraid of not being able to reach a phone when injured or in danger
5. Very concerned with performance reliability (will it work if the house power goes?)

8.1.2 LIMITATIONS OF EXISTING SYSTEMS

Existing product offerings in residential security have been found to suffer heavily from the following limitations:

1. There is not a system in the market that offers remote interrogate
2. Existing motion detectors are an expensive alternative to magnetic switches
3. Only one or two existing systems communicate alarm condition to points outside the home, and then only to a single outside location
4. Existing systems are either installation-intensive or use powerline carrier which has some inherent limitations (see below)
5. The more sophisticated systems/services rely on a recurring monthly charge which insures their inability to growing the mass market
6. Existing systems are generally too high-priced

8.2 THE HOME COMPUTER (HC) AND HOME SECURITY (HS)

8.2.1 WHAT ONLY A COMPUTER CAN DO

The availability of a computer in the home with a CRT screen display makes it possible to provide efficient home security management to consumers.

1. The ability to enter the floor plan into the computer allows the computer to "compute" optimum physical sensor distribution, given the number and types of sensors made available and/or the total system cost budget. (The computer could even generate a plan for system expansion in several expense phases.) Of course, the distribution can also be manually dictated to the computer. In either case, a record of the topology of the installation is kept in memory.
2. The computer can periodically (and automatically) test all sensing devices and update their status in memory. A flag can be displayed on the screen if a failure is detected and made to remain until a status inquiry is made at the console. This increases the reliability of the system tremendously.

3. The computer can display on command the floor plan of the home, indicating location and nature of sensors, as well as their status on last test.

4. Decision algorithms can be implemented in software which can perform redundant checks on sensor signals thereby increasing reliability.

8.2.2 WHAT THE TI COMPUTER CAN DO BESIDES

In addition to above tasks, the TI Home Computer can also implement functions not normally (presently) done by computers:

1. Interface with telephone network.
2. Deliver a user-programmed voice message to an automatically dialed user-specified phone station upon alarm condition.
3. Expect entry of persons/pets at specified programmed times and deliver a "negative" alert (i.e., an alarm that indicates that the expected entry did not occur).
4. Detect and record exits and entries.

8.2.3 DRAWBACKS OF A HOME COMPUTER SECURITY SYSTEM

Drawbacks exist for the Home Computer Security System.

1. Battery back-up of the peripherals which constitute the security controller around the mainframe would be required to operate (detect and deliver alarms) independent of mainframe.

2. Battery back-up for the mainframe that would be required to operate it for, say, 15 minutes in the event of a power outage.

8.2.3 DRAWBACKS OF A HOME COMPUTER SECURITY SYSTEM (cont.)

Another drawback is the fact that less sophisticated, but nearly as effective, standalone security systems can be produced without a computer and would sell for significantly less money. TIs approach to this is to offer a standalone consumer security product (known as TICOM) as well as the HCSS. The idea is that TICOM will sell to the penny pinchers while HCSS will sell to both the more affluent consumer and the consumer that wants a home comupter but needs to justify it in some way, either at the time of purchase or at some future time when he decides to expand this hardware.

We plan to exploit the commonality of both systems thereby achieving good manufacturing economics.

8.3 SYSTEM DESIGN ALTERNATIVES

8.3.1 TRANSMISSION MEDIUM

There are a number of alternatives as to what medium to utilize or the transmission of information between the controller and the peripherals:

1. Wires - creates installation problem
2. Power-Line carrier - not good for all homes
3. Magnetic loop - requires lots of power
4. Radio-frequency carrier - required careful systems design
5. Ultrasonics - does not penetrate walls and susceptible to falsing
6. Infrared - does not penetrate walls

Of these, PLC and RFC are the best choices. However, they each have drawbacks. PLC does not lend itself to multiple-dwelling units because each unit is not electrically isolated from the others on the same power circuit and the amount of frequency spectrum available is limited. Also, there are homes in which some parts of the house are isolated from other parts of the house. In addition, there is a susceptibility to shorts or opens in the house power circuit that may be caused by malfunctioning appliances, etc., as well as the inability to do remote interrogate or activate/deactivate.

With RFC the object is to make the sensors battery operated. This requires a careful system configuration (and protocol) that minimizes battery drain and yet allows two-way communications (i.e., a receiver as well as a transmitter) with the sensors in order that the capabilities of a HCSS be fully utilized. Sensor battery life should be one to five years.

8.3.2 COMMUNICATIONS PROTOCOL FOR SECURITY PERIPHERALS

Regardless of the transmission medium, a communications protocol has to be established that controls the order of a transmission back and forth from the sensors. E.G., should the sensors contend for the channel or should they be polled or should they be allotted individual time slots for transmission, etc. The nature of the protocol can influence the choice of medium and vice versa.

8.3.3 CODING AND FORMATTING OF TRANSMISSION

Independent of the medium and protocol, the data that is transmitted, which in a security system consists primarily of an ID as to which sensor is talking, must be suitably formatted so as to contend with transmissions channel errors and interface with other systems. The format is influenced by the nature of the medium and must support the required protocol.

8.4 SYSTEMS COMPONENTS/FEATURES

8.4.1 SENSORS

The following types of sensors are offered for the HCSS:

1. Magnetic switches
2. IR low-cost motion detectors (w/built-in TR)
3. Smoke detectors (w/built-in TR)
4. Heat detectors (w/built-in TR)

8.4.2 TRANSMITTERS/RECEIVERS

Packaged transmitters/receivers are provided for connection to window (magnetic) switches and also for manual alarm/systems functions:

1. Personal danger
2. Personal injury
3. Remote interrogate
4. Remote activate/deactivate

8.4.3 SECURITY PERIPHERAL CONTROLLER (SPC)

Contains transmitter/receiver and interfaces to mainframe through I/O port. It contains the emergency phone numbers stored by the user and has all the necessary circuitry to communicate with synthesized voice on the phone lines. It also contains a timer and an event counter and handles complete protocol with sensory peripherals. It is battery backed-up. Also, it will be possible to connect a cassette recorder to it and it will be able to record incoming phone calls.

8.4.4 SELF-TESTING AND DIAGNOSTICS

The system will regularly test sensor status and will indicate irregularity on display screen.a Sensor status will be active, dormant, or dead (low-battery). Status is given upon inquiry which may be in response to flag on screen and takes the form of the house floor plan.

8.4.5 TELEPHONE INTERFACE

A complete interface to phone line for security emergencies is provided in the SPC. Features include delivering synthesized voice messages and up to 20 user-entered telephone numbers can be specified.

8.4.6 INTRUSION DETERRENTS

Through its ability to answer the phone and speak phrases into it (e.g., "Please call back in a few minutes") and also through the ability to talk loudly with a local (optional) amplifier, the HCSS will be able to give the semblance of people in the house to callers and prowlers when the home is empty (e.g., when the dwellers are away on vacation). This deterrent can be augmented if the user also has purchased a Home Computer control System (HCSS) which will then allow the computer to turn lights on and off, pull curtains and flush toilets.

8.4.7 PRICING

We are currently estimating a typical system with above features to retail in the $1,000 range -- $300 for the SPC and $300 to $700 for the sensors.

8.5 CONTROL SYSTEMS IN THE HOME

One of the things for which computers appear to be "a natural" is remote automatic control around the house. There is a market research evidence that consumers look at the advent of home computers principally as providing automatic control.

8.6 CONTROL FUNCTIONS BY ACCESS MODE

8.6.1 USER-INITIATED AT CONSOLE (LOCAL)

This mode is used primarily to input control commands that don't require immediate action. For example, to select the operating state of the heating and air conditioning system as comfortable, acceptable or shut-off; to select the temperature setting on the water heater; etc. It is also used for immediate action: e.g., when remotely controlling the lawn mower from the console, closing the garage door, locking or unlocking doors, etc.

8.6.2 USER-INITIATED AWAY FROM CONSOLE (REMOTE)

One type of case in this mode is when the user utilizes a small hand-held control unit it initiate some control action - e.g., when the temperature is "manually" changed (or a status inquiry is made) from bed. The other type of case is when the user calls home on the phone and instructs the system to initiate some action - e.g., when the user wants to turn the kitchen oven on so it cooks dinner as he/she drives home.

8.6.3 COMPUTER-INITIATED AT PRE-PROGRAMMED TIMES

This is simply the case in which actions are initiated as specific times - e.g., turning the heater on in the morning (in winter).

8.6.4 EVENT-INITIATED (LOCALLY OR REMOTELY)

This is the case in which an event causes some action to be initiated - e.g., the detection of someone walking into a room at a certain time of the day could cause the light in that room to come on.

8.7 CONTROL FUNCTIONS BY APPLICATION

8.7.1 ENVIRONMENTAL/ENERGY CONTROL

This encompasses the control of lights, appliances, heating and air-conditioning and water heater under an energy loading program that minimizes the costs of these while staying within the limits set by the operating state, taking into account such factors as time of day, number of people in the house (room), etc. This also includes process monitoring like electric energy consumption reporting.

8.7.2 APPLIANCE CONTROL

This refers to the ability to turn appliances on and off primarily as a function of time of day.

8.7.3 MECHANICAL CONTROLS

Here we are talking about being able to obtain mechanical action like locking doors, opening doors/windows, pulling curtains, etc.

8.8 SYSTEM DESIGN ALTERNATIVES

The same comments made with respect to information transfer with security peripherals (par. 8.3) apply to that with control peripherals, except that PLC is a more adequate transmission medium for appliance controls.

8.9 SYSTEM COMPONENTS/FEATURES

8.9.1 CONTROL DEVICES (PERIPHRALS)

The following types of control peripherals will be offered:

1. On-off power switches with transceiver
2. Thermostat with transceiver
3. Electric eyes to detect events
4. Mechanical actuators with transceivers (probably incorporating small motors to accomplish mechanical motion)
5. Hand-held control units with transceiver

8.9.2 CONTROL PERIPHERALS CONTROLLER (CPC)

This unit performs functions very similar to the SPC (par. 8.4.3) and it is quite conceivable that they would be combined into a single box that could perform as either or both by proper parts selection at the factory.

8.9.3 SELF-TESTING AND DIAGNOSTICS

As in the HCSS, the HCCS will perform regular tests and will maintain a status of the control devices in memory. Status will be reported in tabular form rather than with floor-plan graphics.

8.9.4 REMOTE PHONE CAPABILITY

The HCCS will be capable of receiving remote control commands from the user calling from an outside phone.

8.9.5 PRICING

We are currently estimating a control system with full capability to retail in the $1000 to $1500 range.

9.0 CHIP SET

9.1 OVERVIEW

Chip development for the Home Computer is the only remaining obstacle to timely and cost-effective products introduction. System check-out, and reliability testing are paced by the availability of prototype chips. Initial production will undoubtedly be controlled by chip yields and front-end capability. In addition, TI's obligation to allocate chips between Milton Bradley and CPG may increase the chip availability problem.

9.2 LEADERSHIP APPROACH

When properly executed, the chip design approach for the Home Computer will provide much of the product leadership character. The TMC 0430 ROM (6K bytes) for software modules capitalizes on TI's cost leadership and experience with high density PMOS ROMs. Use of slow, inexpensive ROM with a fast NMOS processor is an innovative approach that will provide long-term industry leadership in solid state software.

Designs being implemented in the TMS 9985 CPU and the TMS 9918 video display processor are state-of-art in functions and process. The 9985 approach was chosen to enhance industry acceptance of the TMS 9900 family and drive costs down the learning curve with Home Computer volume, just as TI's calculator volume helped to provide cost leadership with the TMS 1000 4-bit microcomputer family. Faced with the task of designing a 16-bit microprocessor for an application that has traditionally been best served by 8-bit processors, the Semiconductor Group has aggressively incorporated design and performance features in the 9985 that will provide comparable system performance to any of the currently available 8-bit processors, with some additional flexibility. The TMS 9918 VDP is superior in resolution, number of colors, flexibility and use of moving figures to any currently available chip today and is the most complex logic chip ever attempted by TI. The TMS 9919 capitalizes on TI's I^2L technology to produce a versatile low-cost sound generation chip with features unavailable in any existing IC. In return for the production volume benefits that the Home Computer will provide for the TMS 9900 family, the Semiconductor Group committed a chip set price of $38.50, only slightly higher than that obtainable with a custom 8-bit microprocessor design. Consumer Products personnel realize the importance of making the Home Computer profitable for both SCG and CPG and yield improvement actions have been taken to insure this (see Section 9.5).

9.3 CHIP DESCRIPTIONS

Four new chip designs are being executed for the Home Computer. Progress to date confirms that the pacing design will be the TMS 9985 CPU. Following is a brief description of the function of each chip"

9.3.1 TMS 9985 CPU

Adding significant capability to TI's 9900 microprocessor family, the TMS 9985 is a 5MHz, single 5V supply, NMOS chip with 16-bit instructions and an 8-bit data bus. It will provide the Home Computer central processing and I/O control functions. Up to 64 K bytes of memory can be addressed with the TMS 9985 and four prioritized interrupts and an on-chip timer are included. The instruction set provides minicomputer capability in a low cost home computer system.

9.3.2 TMS 9918 VIDEO DISPLAY PROCESSOR

As one of the most complex designs ever completed at TI, the TMS 9918 VDP communicates with the TMS 9985 CPU, refreshes the TV screen, addresses and refreshes four to 16K bytes of RAM and provides 16 colors, 24 lines of 32 characters with 8x8 dot resolution, 32 movable characters with magnification, 24 lines of 40 characters with 6x8 dot resolution or 48 lines of 64 independent spots. This chip will guarantee the leadership graphics capability of the TI Home Computer.

9.3.3 TMS 9919 SOUND CONTROLLER

Using TI's I^2L technology, the TMS 9919 sound chip will provide tone and noise generation for the Home Computer. It is controlled by the TMS 9985 CPU through eight address lines and provides four-octave, three-voice music capability.

9.3.4 TMC 0430 GROM

Capitalizing upon TI's low-cost PMOS capability, the TMC 0430 graphics ROM provides 6K bytes (48K bits) of ROM program storage. Each software module (GROM) will contain from one to five of these chips. This chip will serve as the basis for a major solid state software business for TI and is similar to the TMC 0540 chip that now costs CPG less than $1 for use in TI-59 programmable calculator solid state software. This chip will not be sold directly to customers outside TI but will be sold in software GROM modules by CPG to OEMs wishing to sell software for TI's, Milton Bradley's or others' home computers.

9.4 CHIP DESIGN STATUS

9.4.1 TMS 9985 CPU

Because of TMS 9940 microcomputer and the TMS 9985 are so similar, they have been designed in parallel by the same design group. Bar size has grown from an original 45Kmil^2 plan to 81Kmil^2 and first-pass slices verified operation of only a portion of the bar. While second pass slices are due on September 15, there is less than a 50% probability that these chips will be functional. In addition, the large bar size increases the probability that the 5MHz speed specification will fall short by at least 20% and that the yield and cost will not satisfy the Semiconductor Group GPM requirements of 22%.

9.4.2 TMS 9918 VDP

Successful operation of over 70% of this bar on the first pass provides a high probability (80%) that these chips will be functional when second-pass prototypes are completed on September 1. Color generation quality is excellent on the first pass chips. The designers in CAMD (SCG) should be congratulated on the fine execution of this difficult design.

9.4.3 TMS 9919 SOUND CONTROLLER

First pass prototypes contained only minor errors and 80% of the bar functions have been successfully checked on the second-pass slices. Evaluation will be complete by August 25 and prototypes will be available for tests in Home Computer simulators at that time.

9.4.4 TMC 0430 GROM

Prototypes have already been tested and approved in the Home Computer breadboard. Probe yield on initial lots exceeded the design-to-cost plan by more than a factor of two, allowing a higher GPM for the Semiconductor Group and potential for Home Computer cost reduction.

9.5 ACTIONS

Since the chip designs provide the highest risk in achieving design-to-cost at required margins for SCG and CPG, and the only significant risk in planned introduction date of the Home Computer, much of the current program effort is directed at the following objectives:

1) Design fo Home Computer modifications to accept chips that are out-of-spec in speed or power

2) Cooperative SCG/CPG yield team effort to insure profitable and sufficient production of chips at the $38.50 committed price.

9.5 ACTIONS (cont.)

3) Formulation of back-up plans in case TMS 9985 functional prototypes are delayed more than one month beyond the present September 15 forecast.

9.5.1 HOME COMPUTER SYSTEM MODIFICATION ACTIONS

Modifications to the Home Computer have already been implemented to accept TMS 9985 parts that are up to 20% over the 750mW specification. Special heat sinking and packaging can be added, at some additional cost, if initial system prototype tests indicate a need. The Home Computer power supply was designed with a 50% margin. Some of this margin has been used to solve other problems, but at least 20% is still available for contingencies.

Design of the Home Computer has now been completed to allow TMS 9985 chips that are below the 5MHz speed specification. Performance of the Home Computer in terms of speed of execution will decrease linearly with frequency but speeds as low as 4MHz could be utilized without major user problems. Because speed performance is a major yield loss in NMOS CPU's of this type, the broadened speed acceptance window will contribute markedly to chip yield.

9.5.2 YIELD TEAM ACTIONS

A TMS 9940/9985 task force has been in place in FEP II for several months addressing critical geometry and process-related problems of the two chips. Recent organizational changes in SCG's MOS Division have brought additional design resources to bear on the TMS 9985 and a parallel relayout of the bar to achieve the DTC bar size has already started. Members of the CPG Component Design Department have also been assigned to serve on a design task force with SCG designers to identify yield-improving design changes on the TMS 9985 and 9918 as soon as functional chips are obtained. Node-for-node chip simulators were built by the Component Design Department and have proved valuable in identifying and analyzing logic errors in the TMS 9985 and 9918 designs.

9.5.3 CONTINGENCY PLANS

Cost and production volumes of the TMS 9985 and 9918 could limit quantities of Home Computer shipments in 1979. Only completion of a functional TMS 9985, however, stands in the way of on-schedule Home Computer product introduction. Since this is the only major program risk, effort is now being directed at back-up alternatives. Use of the existing TMS 9980 (or a minor modification to it) has been considered in detail but no solution has been found that would allow system compatibility with software and peripherals when the TMS 9985 is phased into production.

9.5.3 CONTINGENCY PLANS (cont.)

Use of the TMS 9980 would substantially reduce system performance, cause major changes in completed system and applications software and eliminate the future possibility of home security systems. It is possible, however, that a low-cost version of the Home Computer with no peripheral expandability and minimal or no user programmability could be introduced using the TMS 9980 at the same time the TMS 9985 version is introduced. This would alleviate some of the TMS 9985 chip supply problems but is considered an undesirable alternative because of the limited capability of the low-cost system and the increased difficulty of supporting two products.

Although feasibility is still highly tentative, changes in operating system and applications software could allow introduction of the Home Computerwith some schedule delay but without loss of performance by purchasing a microprocessor such as the Z-80 from a competitor. This is considered highly undesirable because it destroys the basic strategy of using the TI Home computer to create industry acceptance of a 9900 family member that is competitive with popular 8-bit devices.

10.0 RELIABILITY

10.1 MARKET EXPECTATIONS

Development of a new market for Home Computers requires an unprecedented emphasis on reliability. Experiences of initial users of the Home Computer with reliability and repair will determine the rate at which this market can develop and will be the principal factor in TI's image in the market.

Surveys have already indicated that potential buyers of a home computer are particularly concious of reliability problems with electronics products. Warranty failure rates for the home computer must be comparable to other electronic appliances used in the home. Figure 10.1 shows warranties and warranty failure rate for typical appliances. Based upon this data a 5% in warranty return rate has been established as a requirement for initial production units.

Figure 10.2 provides a comparison of the Home Computer with typical DSG products in terms of reliability. The increased stringency of operating environment, MTBF and user capability is apparent for the home computer.

10.2 RELIABILITY ESTIMATE

Figure 10.3 summarizes failures per million hours for each of the key components of the home computer. When usage factors are accounted for, a system MTBF of 12,928 hours is calculated. Equating this to expected usage as shown in Figure 10.3 predicts a 1.3% warranty return rate for a typical home user within the three month planned warranty period. This figure assumes no further effort to improve reliability.

10.3 ACTIONS TO IMPROVE RELIABILITY

The largest expected contribution to failures comes from the mainframe MOS devices. Although TI data indicates a failure rate for the TMS 4027 4K RAMs of only 0.2 ppm device hours, system testing procedures have been planned to verify this level of quality. Actions to evaluate and improve reliability of other MOS devices in the system are summarized in Figure 10.3. Additional system cooling, use of ceramic packages, board level burn-in in system level burn-in time are also under detailed evaluation by the QRA and Home Computer PCC engineers. A special diagnostic GROM has been developed for the system that will control burn-in cycling and test monitoring as well as providing retailers and consumers with a method of varifying proper authorization of their home computers.

10.3 ACTIONS TO IMPROVE RELIABILITY (cont.)

Appendix E summarizes the rigid testing procedures planned for the Home Computer. By conducting tests in parallel, an accelerated reliability qualification can be completed in six weeks without any compromise in testing standards. The schedule assumes that no significant design problems are encountered during reliability testing. For this reason, twelve weeks is allowed for in the prodcut development schedule.

PERSONAL COMPUTER DIVISION
JUNE FORECAST REVIEW
CONSUMER PRODUCT WARRANTY/SERVICE CONSIDERATIONS

CTV
- RCA - ZENITH - GE - MAGNAVOX - SONY - 3 MONTHS PARTS/LABOR
- PANASONIC OTHER JAPANESE - 12 MONTHS PARTS/LABOR
- 19" AND ABOVE - IN HOME SERVICE
- SERVICING RETAILERS PREFER SHORT WARRANTIES SO THEY CAN SELL SERVICE CONTRACTS

HIFI
- ALL MANUFACTURERS - 2 YEARS PARTS/LABOR

MAJOR APPLIANCES
- ONE YEAR PARTS AND LABOR

TRAFFIC APPLIANCES
- OTC PLUS 90 DAYS PARTS/LABOR

IN WARRANTY FAILURE RATES
- SOLID STATE TV MAX - 5%AVG - 3%
- HIGH FE RECEIVERS - 3-5%
  TAPE DISKS/TURNTABLES - 8-12%
- MAJOR APPLIANCES $< 5\%$

FIGURE 10.1

PERSONAL COMPUTER DIVISION
JUNE OPERATIONS REVIEW
DSD-PCD COMPARISON

	DSD	HOME COMPUTER
MARKET	• Low volume, medium-large size business • 24 Hour/Day system useage • Office environment • System integration for customer requirements	• High volume home & small business • 2-8 Hour/Day system usage • Multi-use environment • Standardized system with plug-in options
RELIABILITY GOALS	• Minimize cost of ownership (product cost and maintenance cost) • 1000 Hour MTBF • 1 service call/month for typical system: computer, 2 disk drives, 2 terminals	• Maximize customer satisfaction • 8000 HR MTBF
RELIABILITY APPROACH	• Board level burn-in (2-4 days - Dynamic) • Selected component level burn-in • Qualify major procurement and system with 20 unit, 1000 hr. test ($0^{o}C$ to $50^{o}C$ 24 Hour temp cycle and power cycling)	• System level burn-in • Possible selected component level burn-in • Qualify all components and system to all anticipated environments--temperature, humidity, handling, shipping, power variations, RFI, static discharge and 100 unit 1000 hour life test

FIGURE 10.2

CONSUMER ELECTRONICS BUSINESS OBJECTIVE
HOME PERSONAL COMPUTER

RELIABILITY FORECAST

SUBSYSTEM	λ (FAILURES/10^6 HRS)	% USE	X USE
• MAINFRAME	42.5	100	42.5
• IR RECEIVER	18.3	50	9.15
• HANDHELD TRANSMITTER	18.8	25	4.7
• CASSETTE INTERFACE	3.2	25	3.2
• POWER SUPPLY	14.0	100	14.0
• SOFTWARE MODULES	15.0	25	3.8
SYSTEM			77.35

SYSTEM MTBF = $\frac{10^6}{\lambda}$ = 12,928 HOURS

RETURN RATE (3 MONTHS) = 1.3%

FIGURE 10.3

PERSONAL COMPUTER DIVISION
JUNE OPERATIONS REVIEW

ACTIONS TO DESIGN-IN HOME COMPUTER RELIABILITY

ACTION	POTENTIAL IMPACT	RESPONSIBILITY	COMPLETION
• EVALUATE 85°C BURN-IN OF SELECTED MOS	3PPM/DEVICE	HOSTAK	09/01/78
• COMPARE COST OF MOS BURN-IN TO SAVINGS FROM LOWER FIELD & LINE FAILURES	$0.50/DEVICE	LAWSON	07/07/78
• EVALUATE MOS DEVICES OPERATING AT 70% OF PACKAGE DISSIPATION RATING	3PPM/DEVICE		
• CERAMIC PACKAGE FEASIBILITY		JENSEN	07/15/78
• ADDITIONAL COOLING FEASIBILITY		LAWSON	07/17/78
• EVALUATE COST/BENEFIT OF HIGH REL. TMS 4027	6PPM/DEVICE	WEBB	06/15/78
• EVALUATE HI-TEMP. BOARD-LEVEL BURN-IN	1PPM/DEVICE	LAGRANGE	09/01/78
• DEVELOP DIAGNOSITC SPEC OF GROM FOR BURN-IN CYCLING AND TEST MONITORING	1PPM/DEVICE	LAWSON	06/07/78
• DESIGN-IN ERROR CORRECTION FEATURES		WILHELM	ONGOING

FIGURE 10.4

11.0 ACHIEVEMENT OF FORECAST MANUFACTURING COSTS

11.1 COST FORECAST

Forecasts were developed from:

1. Detailed design review, using sketches, models, electrical schematics, with electrical and mechanical designers.
2. Review of planned assembly process flow with industrial test equipment, assembly and tooling group engineers
3. Comprehensive I.E. line balance and time estimates
4. Time study review with Manufacturing Supervision, Product Engineering and Quality Control Engineering.
5. Labor goals and resulting learning curves that were agreed upon by FCC and PCC personnel.

11.2 CONFIDENCE

If the design has remained unchanged then there would be a greater than 90% confidence level because of the attention to detail in the studies which produced the learning curves. The designs in fact have changed, in some cases significantly, but those changes include both simplifications and additions to the labor content. A complete update of all the labor estimates will be performed after final drawing release. Present confidence levels of our cost estimates are:

Mainframe	75%	Receiver	85%
Software Module	95%	Cassette	80%
Transmitter	85%		

11.3 POTENTIAL PROBLEM AREAS

Following are the key potential problem areas:

1. RFI shielding requirements - Final details will not be known until systems with working chips can be tested. Forecasts are based upon a multiple "can" system. In fact, the complexity would increase to "cans" within "cans" and power supply busses in the form of additional parts soldered to the PCB.

2. Circuit Complexity and ability to troubleshoot - The planned use of "signature analysis" with both manual and computer controlled diagnostic systems gives us a high degree of confidence in our ability to accomplish repairs efficiently. This approach will enable us to use exactly the same procedures in manufacturing as the customer repair center and in the field.

11.3 POTENTIAL PROBLEM AREAS (cont.)

3. Circuit complexity and product reliability - Presently the manufacturing plan calls for all products to be "burned-in" as complete units. The "burn-in" time will initially be 96 hours with reduction only when justified by reliability performance. The mainframe will be "burned-in" using the diagnostic GROM for operation control and multiplexed monitoring of the performance of all units on a rack using a mini-computer. Individual IC "burn-in" is not planned at this time and it would obviously create increased manufacturing costs. An economic study will be completed to determine the "reliability point" at which component burn-in would be justifiable from an overall cost point of view.

   Sockets will be used initially for all "high risk" IC's. These will be eliminated after reliable performance has been demonstrated. It is not anticipated that the use of sockets will preclude the use of the automatic DIP Insertion Equipment.

11.4 MANUFACTURABILITY

Estimates of product manufacturability can be obtained by comparing the Home Computer to existing products:

HC PRODUCT	COMPARED TO	DIFFERENCES	ACTIONS TAKEN
Mainframe	TI 5040	Mainframe has: NO DISPLAY NO PRINTER	
		More complex electronics	• automated in line test • 3060A diagnostic tester
		More keys	• use of well proven "Hytek" keyboard
		More internal and external interconnections	• choice of simplest/lowest cost system
Software Module	TI-1000 series	Much simplier Approximately as complex at TI-59 CROM	• much easier to handle because of size

11.4 MANUFACTURABILITY (cont)

HC PRODUCT	COMPARED TO	DIFFERENCES	ACTIONS TAKEN
Transmitter	TI-58	Comparable electrically Mechanically more complex because of positioner control	• mechanical design has been developed over a long period of time and should not be a problem. • electrical system developed from GROM contacts on TI-59 • coding strip attachment is not proven. Will run evaluations prior to production
		IR Transmitters	• located by case plastics. Not anticipated to be critical
Receiver	TI-58	Comparable electrically but will require training detector	• good tool set design • accurate positioning design includes a seperate plastic part to accomplish.
		Lens	• simple lens located by case plastics. Tests to date do not indidate problems

PERSONAL COMPUTER DIVISION
OPERATIONS REVIEW
HOME COMPUTER CONSOLE COST 1979

	2Q			3Q			4Q		
	FORECAST	WORST CASE	MOD* PLAN	FORECAST	WORST CASE	MOD* PLAN	FORECAST	WORST CASE	MOD* PLAN
IC'S	66.97	71.77	66.97	48.46	66.97	48.46	44.94	66.97	44.94
TRANSISTORS/DIODES	.99	1.05	.99	.95	1.01	.95	.93	.96	.91
TRANSFORMER	4.25	6.00	4.25	4.22	5.97	4.22	4.20	5.95	4.20
POWER SUPPLY	8.54	9.00	8.54	8.44	8.90	8.44	8.42	8.80	8.42
RESISTORS	.66	.70	.66	.62	.66	.62	.60	.62	.60
CAPACITORS	1.55	1.80	1.55	1.50	1.75	1.50	1.50	1.70	1.50
PCB	10.86	12.00	10.86	10.75	11.89	10.75	10.72	11.79	10.72
CABLES/SOCKETS/CONNEC.	3.53	3.54	3.53	3.48	3.49	3.48	3.45	3.45	3.45
PLASTICS	2.05	2.40	1.63	2.05	2.40	1.63	2.05	2.37	1.63
MECH PARTS/LABELS	1.62	1.62	1.62	1.58	1.58	1.58	1.56	1.56	1.56
KEYBOARD	5.01	5.01	5.01	4.91	4.91	4.91	4.89	4.89	4.89
OVPK + MANUALS	3.80	4.60	1.20	3.70	4.50	1.18	3.70	4.50	1.18
OTHER/OVERLAYS	8.84	10.00	6.87	8.80	9.96	6.83	8.77	9.93	6.80
TOTAL MATERIAL	118.67	129.49	113.68	99.46	123.99	94.55	95.73	123.49	90.82
LABOR + OVERHEAD	15.24	18.00	15.24	12.39	14.62	12.39	10.20	12.05	10.20
TOTAL MLO	133.91	147.49	128.92	111.85	138.61	106.94	105.93	135.54	101.02
OOH	38.27	38.27	38.27	18.25	18.25	18.25	12.19	12.19	12.19
COST ADJ	2.53	2.53	2.53	.95	.95	.95	.28	.28	.28
PROD. SUPP.	35.10	35.10	47.69	35.10	35.10	50.14	35.10	35.10	56.81
COB	209.81	223.39	217.41	166.15	192.91	176.28	153.50	183.11	170.30
GPM	50.19	36.61	42.59	93.85	67.09	83.72	106.50	76.89	89.70
AUP	260.00	260.00	260.00	260.00	260.00	260.00	260.00	260.00	260.00
RETAIL	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
TI GPM%	19.3	14.1	16.4	36.1	25.8	32.2	41.0	29.6	34.5

* JRP

11.4 MANUFACTURABILITY (cont.)

HC PRODUCT	COMPARED TO	DIFFERENCES	ACTIONS TAKEN
Cassette		Private label purchased from vendor	• minimum labor content for any additional packing requirements

11.5 SKILL REQUIREMENTS

Meetings have been held to identify the skills required to build and provide Product Engineering support for the range of Home Computer Products. Specific training courses have been identified and planned Product Engineering technicians will be assigned to the design group for training prior to production. Manufacturing will retain operators with the necessary skills and provide training programs for all new operators and supervisors. Special skills required will be identified and operators who meet the requirements will be assigned to the specific areas (e.g. computer terminal experience).

11.6 WIP CONTROL

Systems are being developed for both material and scrap control and will be in place before production start up. Particular emphasis will be placed on quick detection and correction of out-of-control situations.

11.7 MATERIAL COSTS

Figure 11.1 summarizes the material costs in the present design. Potential exists for reduction of some of the R/F shielding costs. Present systems costs are consistent with the planned $260 AUP and $400 suggested retail price at introduction. Ability of the Semiconductor Group to meet its $38.50 chip kit price guarantee is the only major remaining risk. As discussed earlier, choice of retail price versus maximum organizational profit from the pricing matrix would be affected by any change in material cost. A product strategy would still exist with chip price increases to as high as $60.21 but either a higher level of product support or a lower level of NUB would be required to maximize organizational profit. A retail price of $500 would be required in this case. This is still below the $698 ARP of the least expensive competitive unit (TRS-80 Level II BASIC) but a retail price of $500 would delay the period of product acceptance by the non-business mass market. For this reason, actions are being concentrated on the chip yield team programs to minimize the reminaing risk in the part of the home computer material cost.

12.0 SERVICE SUMMARY

In order to insure a successful service strategy, expediency demands that the home computer be marketed through retailers who have an existing service organization to guarantee immediate customer satisfaction and the resultant rapid market growth. Profitability demands that CPG provide full service for all its personal computer products as soon as it is possible to do so. Service performed by third party companies, dealers or other service PCC's in TI represents lost CPG revenue.

An example is shown in Table 12.1

TABLE 12.1 H.C. PROJECTED MAINT. CONTRACT INCOME

		1979	1980	1981
Cum Inst. Base	(KU)	120	360	710
Mnt. Cont. in Force	(KU)	100	280	600
Value Cont. in Force	(K$)	2500	10500	24950
GPM	(%)	15	20	25
GPM	(K$)	375	2100	6238

If the home computer mainframe costs $115 MLO and TI receives 50% GPM, the original sale GPM is $60. An analysis of service related GPM is $80. Since the service income is spread over five years it represents a means of almost doubling original sales profit during product life.

The home computer service strategy is therefore to work with servicing dealers for immediate sales and service and the TI-DSG field servcie branch for long range full TI service. Part of the long range plan will be careful phasing in of TI Field Service such that the distribution network is minimally disturbed.

12.1 CUSTOMER DIRECTED SERVICE FEATURES

The customer is the object of a service strategy. Table 12.2 lists the service features he will be offered.

TABLE 12.2 HOME COMPUTER SERVICE

1) 90 day unlimited warranty

2) Maintenance contract with reduced point of purchase price for months 4-12. A tentative schedule is shown below. Note that IN HOME service is offered at a higher price.

	TYPE SERVICE	COVERAGE	POINT OF SALE	9 MOS 4-12	2ND YR 13-24	3RD YR 25-36	4TH YR 37-48
MAINFRAME	IN HOME	4-12	24	27	45	54	63
SYSTEM	IN HOME	4-12	26	29	47	56	65
MAINFRAME	CARRY IN	4-12	15	17	26	33	40
SYSTEM	CARRY IN	4-12	17	19	28	35	42

3) If the customer declines a maintenance contract he will have warranty coverage, after which he will be given in-home or carry-in "demand service" at his option.

4) The Home Computer will have a self test diagnostic GROM which will tell the customer to a 95% confidence level that his computer is functioning properly. If it is not, service is called for and the Home Computer will also have diagnostics which will aid the service personnel with proper test equipment.

5) Over the counter exchange will be offered in selected areas and rolled out nationwide as production and profit levels permit.

6) The customer will have technical support available either through the dealer or directly from TI, at the dealer's option.

Figure 12.1 shows the relationship between TI, the dealer and the customer.

12.2 WARRANTY

A ninety day unlimited "carry-in" warranty is planned. Customers will be able, to have in-home service under warranty coverage at the dealers option. It is likely that the dealer will establish a mileage charge which will be customized to the local area. Such a practice essentially transforms the "unlimited ninety day carry-in warranty" to a "limited ninety day warranty".

TI will pay dealers a fixed price labor schedule for each in-warranty failure. Failed sub-assemblies will be shipped to Lubbock, repaired and returned to dealers at no charge. Table 12.2 shows a preliminary warranty labor schedule.

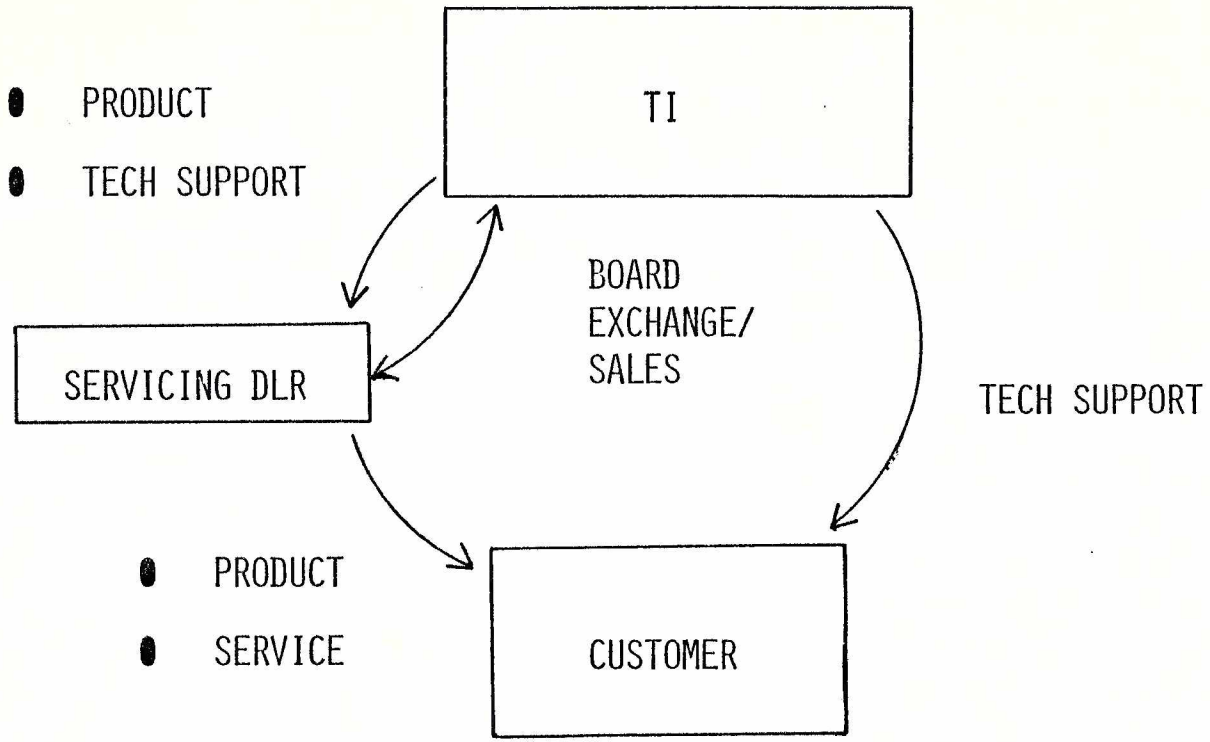


FIGURE 12.1 TI, DEALER, CUSTOMER RELATIONSHIPS

TABLE 12.2 -1 WARRANTY REPAIRS LABOR SCHEDULE

SUB-ASSEMBLY	LABOR PAYMENT
KEYBOARD OR CPU	$20
POWER SUPPLY	7
IR XMTR/RCVR	5
CASSETTE	3 and exchange
MAJOR ADJUSTMENTS*	5

Dealer will be expected to return an "installation notice" form at time of sale with product information and customer's signature. Subsequent in warranty repairs will have to be accompanied by "in warranty repair" paperwork which will also have customer's signature affixed stating he (she) has received repairs within the warranty period. It is expected that the dealer will absorb the expenses incurred as a result of "no-fault" service. "No fault" Service occurs when a customer brings in a unit for service and either he is having operational difficulties or a minor adjustment is required which is not covered in the warranty payment schedule.

* Major adjustments should be specified. A demonstrated software failure will fall under this category.

12.3 LUBBOCK REPAIR CENTER

Dealers will own their own service sub-assembly inventory. They will return failed sub-assemblies to the Personal Computer Service Repair Center in Lubbock. Replacement boards will be immediately shipped and the bad boards will be input to the repair cycle which is shown in Figure 12.3-1. The cost of repairing in-warranty boards will be absorbed by the product PCC. Out of warranty repairs will be billed to the dealer. A preliminary estimate of repair costs is shown in Table 12.3-1.

TABLE 12.3-1 PRELIMINARY REPAIR COST

	REPAIR COST			
	MTL $	DIAGNOIS HRS/FAIL.	REPAIR HRS/FAIL	MLO TOT $
RAM EXPANSION	2	.5	.5	12
SOFTWARE MODULE	0.30	.5	.3	9
IR RCVR/XMTR	2	.3	.5	10
CASSETTE		RTV		
KEYBOARD	6	.3	.3	12
MAIN LOGIC BOARD				
o POWER SUPPLY	3	.5	.5	13
o MEMORY	2	.5	.5	12
o MAIN LOGIC	6	.5	.5	16
o CASSETTE CONTROLLER	3	.5	.5	13

12.4 LONG RANGE SERVICE STRATEGY

The Field Service Branch in DSG is the key to a Texas Instruments complete customer service capability. They maintain a TI-CARE system which includes a nationwide network of eleven DXS-20's all linked together and tied to a DXS-40 in Houston.

The DXS -40 in Houston is linked to CIC in Dallas. The TI-CARE system was started in June of 1976 and the experience base and capabilities have since expanded considerably. DSG is interested in expanding the Field Service Branch to cross group lines, servicing whatever products other TI groups may produce. The present effort to link the CPG Personal Computer Service PCC to the TI-CARE system and use the DSG Field Service Branch to service the SR-60A represents a pioneer effort in this regard. An effort to modify accounting procedures and existing IS&S programs is in place to complete this effort. The completion of the computer link is planned for November 30, 1978.

Having completed such a link it is to DSG's and CPG's advantage to continue expansion of this service capability to ultimately comprehend a low cost consumer service strategy. DSG is currently working on this including market research and planned meetings with National Retailers such as Sears. A mutual benefit exists for both Groups. The large installed base planned by CPG will enable DSG to hire more customer engineers, reducing travel time and costs per call. More service centers can be established, reducing customer travel time and thus; making it more feasible for him to bring his product in for service. GPM on maintenance contracts will be higher if the business is expanded properly and costs controlled. The proliferation of personnel and facilities will enhance the sale of maintenance contracts and the inverse relationship of volume vs costs should apply.

Another key to a successful long range service strategy is repair automation. TI-CARE will enable diagnostic repair to remote sites when it becomes cost effective to design products to comprehend such a capability. Customers can then have parts shipped direct to their home or stop at the "neighborhood TI service center: and pick up a part, or leave the unit for same day service. The ultimate long range service strategy is to design units such that failure is a rare occurance. When this is accomplished in parallel with repair automation the repair automation facility can devote itself to enhancing functionality of the product, such as providing the customer with bulletins, software catalogs, notices of new features available, etc.

12.5 FUNCTIONAL REQUIREMENTS FOR DSG/CPG LINK

An interaction of the nature of that which exists between Jim Ricks, Field Service Branch, DSG, and the Computer and Terminals Service PCC's is to be established for the Lubbock-based Personal Computer Service PCC. The object is to enable the DSG Field Service Branch to perform service on CPG products at the customer site and at DSG regional repair centers. Inventory and accounting control will be maintained on existing DSG FIS and Flowline Systems. The purpose of this specification is to document the functional requirements of the Personal Computer Service PCC As related to the IS&S built systems.

12.5.1 INVENTORY

CPG will own all CPG-related inventory and the concomitant liability for losses, in the field and through the repair cycle. Consumer Products will ship product sub-assemblies to DSG field offices. The order quantities will be set by Standard Issue Quantity (SIQ), the latter to be determined by product failure analysis. Orders will be initiated in the field automatically by FIS when the local field office stock reaches the reorder point (ROP).

A stock request (SR) will be received in Lubbock. Orders will be made up from a Personal Computer Service Repaired Inventory Stock and shipped directly to the requesting DSG field offfice. The DSG inventory tracking system will be automatically notified such that the DSG field office inventory and the central system (Flowline) will track reality.

12.5.2 REPAIR CYCLE

DSG Will ship inoperative sub-assemblies to Lubbock where they will enter the repair cycle as shown in Figure 12.5.2-1. The input to the repair cycle in Lubbock will be an Incoming Bin (IB) where goods will await log-in and Q.C. inspection. The IB sources will also be Dealers (TI-external) and TI-Lubbock manufacturing finished goods stock. After log-in processing, goods will go to one of two bins, the Hold for Repair Bin (HRB) or Q.C. test and then Hold for Shipment Bin (HSB). The remainder will go the HRB. Material which is obsolete will dump out of the HRB to the scrap bins (SB). The system must comprehend the three categories of received material. Whole units which must be returned to the user must be tracked. Ideally goods in the HSB should be shipped as soon as notice of an impending shipment from the field is received such that the goods cross in the shipping process, minimizing material float time. The HSB contains the Personal Computer Service PCC's finished repair inventory stock in Lubbock. The total inventory stock will be shown in

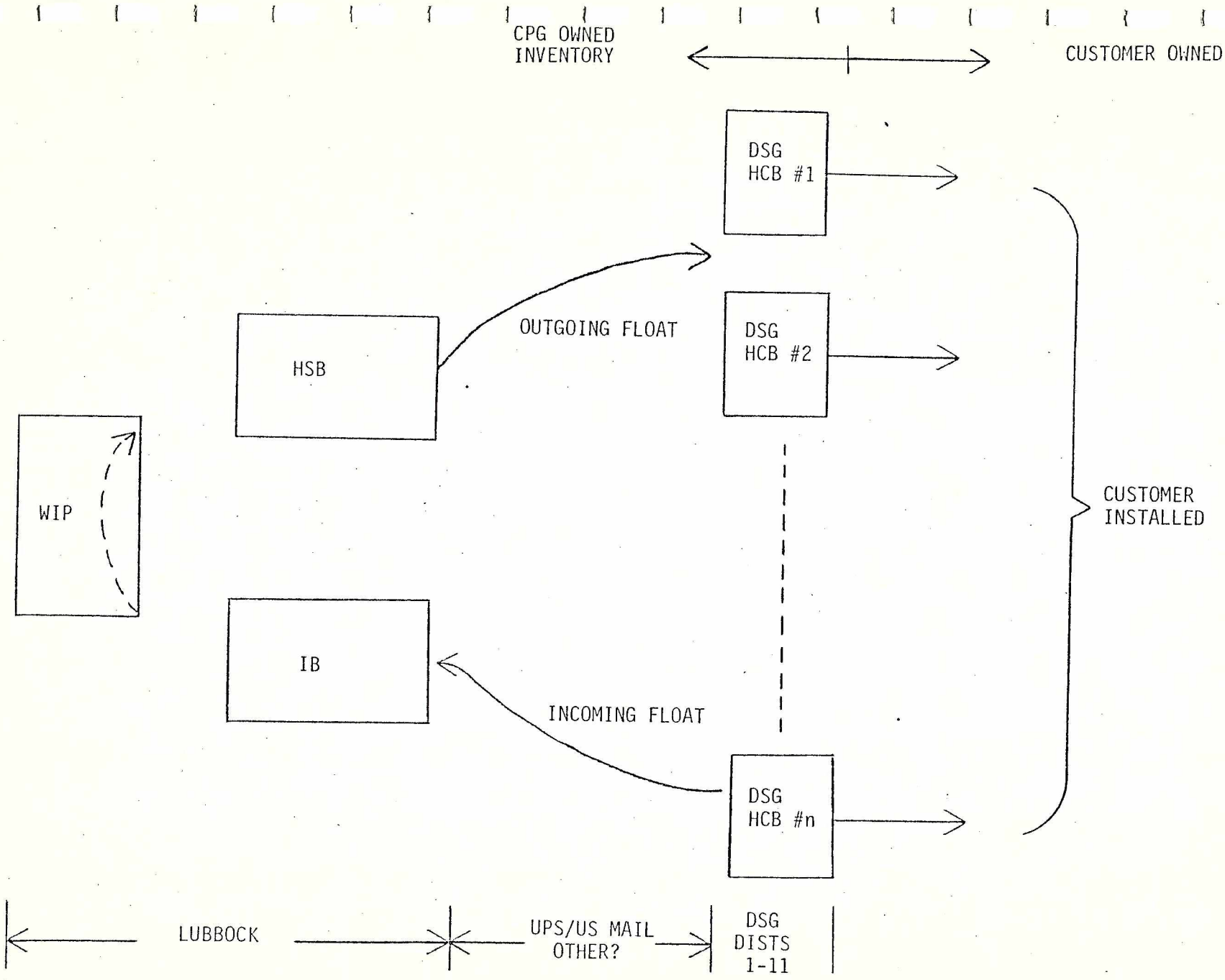


FIGURE 12.5.2-1 PERSONAL COMPUTER SERVICE OWNED INVENTORY STOCK

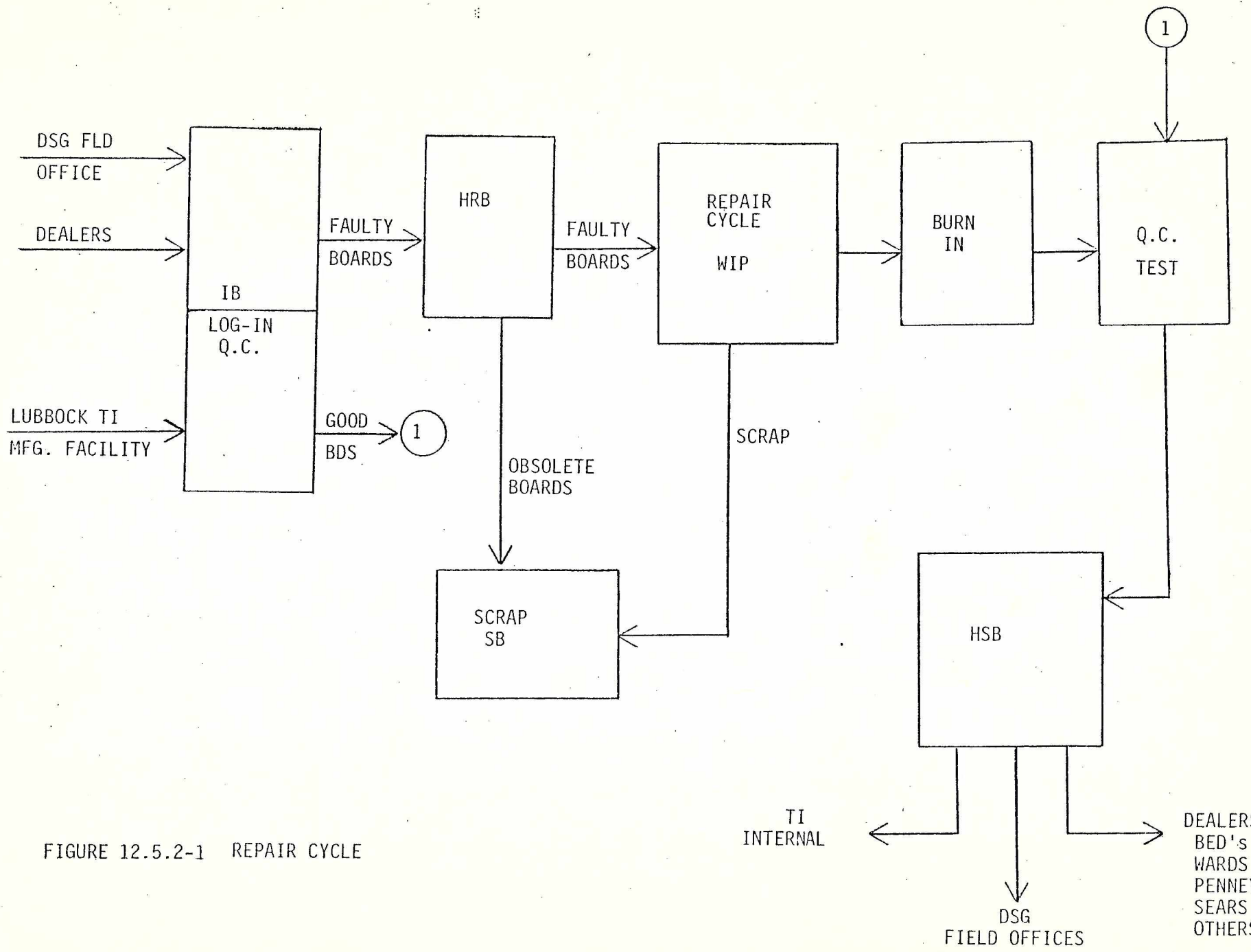


FIGURE 12.5.2-1 REPAIR CYCLE

Firure 12.5.2-2.

It will reside in Lubbock in the Incoming Bin, work in process Hold for Shipment Bin (HSB). There will be ongoing float and incoming float. At the DSG sites inventory will reside in the DSG field office and in customer engineer's mobile vans. It is owned by CPG until a service ticket is processed at the field office after repair. At that point FIS places the part in an "in transit to factory status". It is expensed to the Personal Computer PCC at that time and remains in that status until processed in Lubbock at log-in. At that state it is removed from in-transmit status and put in "factory inventory" status at standard manufacturing cost. Credit is received on DSG books against the expense taken and a reserve is set up against that board such that it passes through WIP at zero net "system value". After passing final Q.C. and logging into the HSB the reserve is removed and the part resides in HSB at standard manufacturing cost. If that part is never reparied it remains permanently expensed against the CPG inventory. In-warranty repairs must be tracked (MLO) so Product PCC's can be charged.

12.5.2 REPAIR CYCLE CONTROL

The following are the Perosnal Computer requriements for inventory control. Since it will be CPG-owned until the customer receives it the financial status will be broken into locations, as shown in Table 12.5-1.

TABLE 12.5.3-1 INVENTORY SUMMARY

PRODUCT	LUBBOCK	FLT OUT	FLT IN	DSG	TOTAL
SR-60	$XXX	$YYY	$ZZZ	$AAA	$BBB
PROD A					
PROD B					
'					
'					
'					
'					
PROD N					
TOTAL	$XXX	$YYY	$ZZZ	$AAA	$BBB

The Lubbock category should be broken into the categories shown in Table II.

TABLE 12.5.3-2 LUBBOCK

PRODUCT	I.B.	HRB	SR	WIP	BURN-IN	Q.C.	HSB	TOTAL
SR-60	$XXX							
PROD A								
PROD B								
'								
'								
'								
'								
PROD N								
TOTAL	$XXX							

The DSG column in Table 12.5.3-1 should have a matrix breakout by district showing summary of inventory dollars on each CPG product.

The IB column in Table 12.5.3-2 must show source breakout, i.e., amounts and sub-assembly tracking on each dealer and DSG district. In addition, the Lubbock caegory must breakout a summary of dealer owned inventory and PCS PCC owned inventory. Only the latter should appear in Table 12.5.3-1.

13.0 FEDERAL COMMUNICATIONS COMMISSION CERTIFICATION

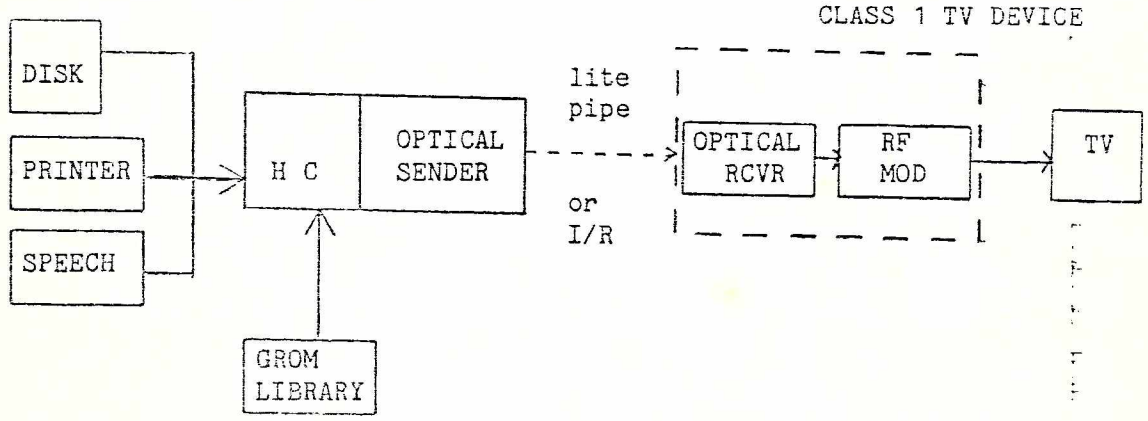
13.1 FCC REGULATORY AUTHORITY

The FCC requires that devices which provide a video modulated, radio frequency carrier on frequencies allocated for television broadcasting be Type Approved subsequent to Subpart H - Class 1 TV Devices of Rule Part 15.

Type Approval is an FCC authorization procedure which requires that the piece of equipment be examined and measured by the Commissin at its laboratory. The submitted unit must satisfy all requirements of the applicable rule part prior to a grant of Type Approval.

13.2 REQUIREMENTS

Although FCC certification was considered at one time to be a major risk for the Home Computer, an approch has been developed that virtually guarantees FCC qualification as a non-pacing element in home computer development. Prompted by a suggestion from George Heilmeier, a fiber optic link was designed to connect the Home Computer to an external RF modulator. A meeting was held on August 10 with FCC personnel to present this approach. They readily accepted the approach, designating the Class I TV Device as the optical receiver and RF modulator as shown below:



The FCC personnel indicated that they may issue a ruling within the next few months eliminating the need for the fiber optic connection and requiring qualification of only the RF modulator. Final stages of design of the Home Computer in the next few weeks will include completion of the light fiber prototype and submission of the modulator/optical receiver to the FCC. The design will be done in such a way that a last-minute change to a cable connection to the RF modulator can be quickly implemented for cost reduction if the new FCC ruling is issued. Peripherals will also be a source of

radiation; many will be of the "smart" variety and will possibly generate signals of their own. Peripherals may be used in a variety of system configurations and the FCC presently requires that each possible configuration be tested. The FCC also requires that software be tested until they are satisfied that the computer has enough margin to accept a variety fo software without exceeding the limits. The software and peripheral testing burden will be tremendous. This is a serious problem that must receive attention.

13.3 ACTIONS TO INSURE COMPLIANCE

13.3.1 MAINFRAME

Extensive use of shielding is planned on both a subsystem level and a total printed circuit board assembly level; in effect, double shielding will be provided for the most critical areas. Various types of shields, including metalized plastic shields, will be examined. Careful PC board layout will provide maximum ground areas. Path lengths for high speed lines will be minimized. Individual IC packages will be bypassed and internal cables will be bypassed and filtered with torroidal chokes where necessary. Optimum routing of individual cables will be determined.

13.3.2 PORTS

DC and audio lines will be bypassed; feed thru capacitors will be used as bypasses where necessary to provide broadband attenuatuion. Toroidal chokes of ferrite beads will be used as requried. Digital lines will be bypassed to the extent allowed before waveforms are degraded unacceptably. Bypasses will be physically located to provide maximum benefit. The connector type and connector-to-board interface will be chosen to minimize pick-up and maximize shielding.

13.3.3 CABLES

The antenna effect of the cables is anticipated to be the most difficult to reduce; in particular, the peripheral and GROM cables which will carry high-speed digital signals. A simple breadboard has been built to simulate the peripheral I/O and GROM drivers and has been utilized in an effort to identify cable isolation techniques.

Flat ribbon cable, both shielded and unshielded, has been tested. Twisted pair cable, shielded and unshielded, has also been tested. As might be expected, the shielded twisted pair cable is most effective, providing a 20 dB to 30dB Improvement over the flat cable. Double shielding techniques will be examined. Dedicated cables for critical functions (CRU, clock, etc.) may be required.

Cables for the other parts will be less critical and tests will be performed to identify the most cost effective alternative. Simple 4 or 5 wire, shielded cables are anticipated.

13.3.4 ADDITIONAL CONSIDERATIONS

Although elimination of much of the expensive RF shielding in the console could cause major cost reduction, current plans are to proceed with this "worst-case" shielding design and eliminate portions of it as a cost reduction after initial prototypes are tested for RF emissions. There are two reasons for doing this:

1) The TI Home Computer could suffer user dissatisfaction and bad publicity if it interferes with adjacent televisions, despite the fact that such interference may be fully within the law as interpreted by the FCC.

2) A proposed Docket 20780 is under evaluation by the FCC that would apply a reasonable limit of 100uV/m in the relevant frequency range to any electronic product, regardless of whether it attaches to a TV. Final ruling on Docket 20780 is not expected for about a year. Our current plan is to provide shielding so that the TI Home Computer can qualify under the proposed Docket 20780 and then to work with the FCC during the next year to help them anticipate any problems with the proposed procedure.

13.3.5 SYSTEM TRADEOFFS

Many system compromises mayl be necessary to meet the 100 u V/M Limit and particular attention will be required not to degrade customer appeal. Speed tradeoffs will be examined; lower speed digital signals can effectively reduce the spectrum of radiated emissions. Cable length will also be examined; shorter cables are less efficient radiators. The number of lines leaving the mainframe will be examined and reduced to an absolute minimum. Cable types and configuration will be examined; techniques approaching conduit will be avoided.

Many of the actions necessary to insure compliance will result in increased cost. In all instances a thorough examination of the alternatives will be made in order to arrive at the most cost effective system. Cognizance of the schedule will be maintained and recognized in tradeoff decisions.

14.0 SUMMARY

It should be apparent from this White Paper that TI has all of the actions and contingency plans in place to insure a timely, profitable leadership entry into the home computer market. The market has been thoroughly analyzed and characterized and the product and its software have been designed to appeal to the market as no previous product has done. Two upsides exist in the present sales plan. First, it includes only the consumer and part of the home programmer segments; the Home Computer's superior price/performance may well add significant penetration of the hobby market that presently running at 100KU/year. Second, our penetration estimtes of the "hardware-pull" markets such as chess players and investment speculators could be quite low. Thus, we have good confidence of achieving the billings and penetration plans for 1979 and beyond.

The only real barrier to the success of the Home Computer is the TMS 9985 CPU chip, and the overall cost/yield of the chip kit. Actions are in place to solve these problems. If the worst possible case occurs, and the TMS 9985 cannot be produced at all, one of the back-up positions with an alternate CPU will be implemented with no more than a three-month delay in introduction.

APPENDIX A

A

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED

THE ATTACHED HOME COMPUTER PRODUCT SPECIFICATION COVERS ALL ASPECTS OF THE SYSTEM AS WE UNDERSTAND IT AS THIS TIME.

WALLY RHINES _____ DATE _____

HERMAN HARRISON _____ DATE _____

C.B. WILSON _____ DATE _____

GARY WILHELM _____ DATE _____

REV																															
SHEET																															
REV STATUS OF SHEETS	REV																														
	SHEET																														

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
ANGLES ±1°
3 PLACE DECIMAL±.010
2 PLACE DECIMAL±.02

IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY

INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100

DWN DATE
CHK
ENGR
QA
APVD
CONTR NO
DESIGN ACTIVITY RELEASE

TEXAS INSTRUMENTS
INCORPORATED
Equipment Group Dallas, Texas

PRODUCT SPECIFICATION
HOME COMPUTER SYSTEM
JULY 24, 1978 TI STRICTLY PRIVATE

SIZE	CODE IDENT NO	DRAWING NO
A	96214	

SCALE SHEET

TI-0923-C

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 SCOPE

This specification describes the physical, electrical, environmental, documentation, and system software requirements of the Home Computer. This document provides the basis for detailed hardware and software specifications.

1.2 PRODUCT STRATEGY

The Consumer Group Personal Computer Strategy consists of Consumer (Home Computer) and Commercial (SR-60 and SR-70) computer product strategies. The product strategies are driven by their market requirements, with resulting differences in performance characteristics. There will, however, be commonality of features between product strategies, as defined by a Review Committee. Styling, user interface, user languages, communications, and peripherals are specific areas of commonality which will strengthen the overall product line and will coincidentally simplify development efforts.

The Home Computer (H.C.) will be a true consumer computer with an appropriate market price point to achieve maximum profit. The H.C. must execute a wide variety of software packages for information, education, and entertainment in the home, working with a home color TV. The system must be compatible with future additions of peripherals, software modules, and hardware changes for an extended period of time. The system must be able to be introduced in Europe shortly after U.S. introduction, and the system must be competitive in both cost and performance with other systems that will be entering the market both prior to and after introduction. The two most important ingredients for the success of the Home Computer are its ease of use and its ability to be a real problem solver. The H.C. will be positioned as a useful home appliance that saves you time to devote to other things, saves money to divert to other uses, protects you, contributes to your children's education, and is fun to use in the process.

1.3 PRODUCT FEATURES

The following are featuers of the Home Computer product:

1) 40-key staggered QWERTY travel keyboard
2) Solid State Software (TM) GROM plug-in module (SR-62 compatible)
3) H.C. BASIC (SR-62 compatible)
4) H.C. Graphics Language (SR-62 compatible)
5) Wall mounted console transformer UL approved; CSA and European versions planned
6) TV speaker and volume control utilized
7) External video input; composite video and RF output
8) Interface for up to two audio cassettes (SR-62 compatible)
9) 44 pin (I/O) peripheral connector (SR-62 compatible)
10) System provides music, communication, and synthesized speech
11) Selector switch for CH 3 or CH 4
12) 110 volts, 60 cycle for U.S.; available with monitor for Europe
13) Mini-earphone jack
14) Remote handheld units/keyboard that operate over an infrared link

1.3 PRODUCT FEATURES (continued)

15) BASIC interpreter executes 30-40 lines of code per second; can contain
16) 50-70 line program in simplest machine; Graphics Language execution rate is 4500 instructions per second
17) User changeable RAM expansion modules of 4K bytes
18) System designed to accommodate future peripherals
19) Large selection of Solid State Software (TM) including that of Milton Bradley
20) System is Federal Communications Commission approved Type I TV Device
21) Warranty

2.0 APPLICABLE DOCUMENTS

- TMS 9985 Microprocessor Data Manual
- TMS 9918 Video Display Processor Specification
- TMS 9919 Sound Generation Controller Specification
- TMC 0430 Graphics Read Only Memory Specification
- TMS 4732 Read Only Memory Manual
- TMS 4027 Random Access Memory Manual
- TMS 9901 Input/Output Controller Manual
- ASTEC RF Module Specification (TI Specification 1501513)
- Home Computer Graphics Language Specification
- Home Computer BASIC Specification
- Home Computer Monitor Specification
- Home Computer Floating Point Specification
- Home Computer Replay Calculator Specification
- Home Computer Number Magic Specification
- Solid State Software (TM) Module Specification
- Drawing Tree
- National Safe Transit Preshipment Test Procedure
- UL STD 461A; 462 Methods CS01, CS02, CS06, RS01, RS02, RS03
- FCC Rules and Regulations, Part 15 Subparts, A, B, & H and Part 2, Subpart J
- Detailed System Specification
- Peripheral Specifications: RAM Expansion Specification, Cassette Peripheral Specification, and Infrared Controller Specification
- Home Computer System Memory, CRU, and Interrupt Mapping Specification

3.0 GENERAL DESCRIPTION

3.1 SYSTEM HARDWARE

A block diagram of a complete Home Computer system is shown in Figure 3.1.A. Although the initial Home Computer is not being designed as a time-sharing machine, considerable expansion capability and versatility has been designed in. One external vectored interrupt is available. Some of the key units shown in Figure 3.1.A are:

3.1.1 CONSOLE

The Home Computer will be packaged and styled in a low-profile console designed to be attractive in the home living area. The mainframe will have the capability to

interface with a number of peripheral devices with connectors placed to the side front and rear of the unit. Expansion of both ROM and RAM memories is possible and the I/O lines and CRU address space is accessible to an almost unlimited range of peripheral devices and applications. To the front and clearly visible on the console is an entry port for programs contained in GROM Solid State Software (TM). Each module can contain up to five TMS 0430 chips or a maximum of 30K bytes of program. One potential future peripheral is a solid state module library which will accept eight GROM modules and will plug into the GROM module port in place of a single module. Library modules can then be addressed via the CRU bus. The user can also input programs and data using the 40-key QWERTY keyboard of the mainframe.

One peripheral connector is provided to accommodate up to four peripherals. An optional expansion chassis is planned to plug into that connector and provide connections for up to eight devices in the future.

3.1.2 OPTIONAL ACCESSORIES

3.1.2.1 REMOTE HANDHELD UNITS (HHU'S) - ENTRY PRODUCT

On the top of the mainframe console there will be an inset for a receiver unit for the infrared remote controlled handheld units. The receiver will interface to the CPU through the TMS 9901 I/O controller. Each remote handheld transmitter contains a digital joystick and a 5 x 4-key keyboard. These will be used as data entry units for control of a movable cursor and competitive activites on the video display. The joystick will be capable of resolving angles as small as 4.5^{0}. The wireless remote capability will offer users freedom of movement and flexibility in the placement of the console. Two of the handheld transmitters can be placed together in a cradle to form a remote 40-key keyboard. An overlay on this cradle provides a complete 40-key QWERTY keyboard to permit 'remote' program or data entry.

3.1.2.2 CASSETTE TAPE UNIT - ENTRY PRODUCT

To provide mass nonvolatile memory data storage capability, we will offer a magnetic tape cassette recorder interface for the Home Computer. This will input/output data through the CRU to the CPU. The Home Computer will interface to TI's custom cassette recorder but will also work with a number of commercial cassette recorders. The TI custom cassette will provide the added feature of software control of queueing initially, with the later addition of automatic recording, playback, and start/stop control.

3.1.2.3 SYNTHETIC SPEECH/LANGUAGE SYSTEM - FUTURE PRODUCT

An important early peripheral to the Home Computer will be a synthetic speech module which utilizes the synthesizer chips similar to those currently used in the Speak & Spell product. The synthesizer will expand upon the Speak & Spell concept and make possible a library of vocabulary words enhancing the educational features of the Home Computer and adding to its expected novelty and utility. The synthesizer will attach to the CRU bus of the mainframe and be controlled by software routines. It

3.1 SYSTEM HARDWARE (continued)

will also be possible to make use of speech libraries.

In addition to an expanded Speak & Spell application, it will be possible to add word prompting to many of our programs. For example, the Number Magic Program can provide verbal prompting or could inform the players of the winner.

There will be a 250-word internal vocabulary and the ability to add words with each software module.

3.1.2.4 THERMAL PRINTER - FUTURE PRODUCT

The primary method of data output on the Home Computer will be the home TV set. For those users who need a permanent record of their data, an optional thermal printer will be made available as a peripheral. This unit will attach to the CRU and receive output data under CPU control. The printer will support 32 columns of print which matches the TV screen format and will allow the VDP to display complementary data or program text simultaneously while printing or plotting relevant data. The electromechanical mechanism will be common with the SR-62.

3.1.2.5 TELEPHONE MODEM/DAA - FUTURE PRODUCT

The Home Computer will have telephone communications capability through an optional telephone MODEM. This unit will attach to the Home Computer through the CRU bus. A telephone answering capability will enable the user to pre-arrange a data link with another system during the early hours of the morning and data transfer can occur unattended. The heart of this system will be the TI CCD MODEM chip currently under development and will couple to the telephone lines directly.

3.2 PHYSICAL REQUIREMENTS OF CONSOLE

Since the console is the heart of the system, it will be described in more detail at this point. General features of the console are labeled in Figure 3.2.A. A basic Home Computer consists of:

1) assembled and tested console
2) attractive packing box
3) electronic television hookup
4) user changeable overlays for Replay Calculator, Number Magic, and joysticks
5) instruction manual with warranty card
6) owners guide to basic programming

Physical and software compatibility with Milton Bradley applications modules is a requirement.

3.2.1 WEIGHT

The total weight of the Home Computer console shall be less than five pounds.

3.2 PHYSICAL REQUIREMENTS OF CONSOLE (continued)

3.2.2 SIZE

Nominal dimensions shall be:

Length:	10.2 inches
Width:	15.0 inches
Thickness:	2.5 inches

The case outline shall be as shown in Figure 3.2.A.

3.2.3 PLASTIC PARTS

3.2.3.1 CASE

The top and bottom cases shall be made by the injection molding process, with attractively styled metal overlays.

3.2.3.2 KEY TOPPERS

The key tops shall be the approximate size of 0.4" x 0.65" and configuration of 0.75" x 0.75" and manufactured using a double shot molding process.

3.2.4 POWER SOURCE

The Home Computer shall be powered directly from 120 volts AC 60 cycle house wiring. Power transformer shall be mounted at the wall socket. No battery backup is currently planned in this system. The power cord shall be approximately sixteen feet long. An optional transformer/cord will be required for European usage.

3.2.5 ON/OFF SWITCH

The Home Computer shall include a front panel On/Off switch with an LED light which indicates when the Home Computer is on.

3.2.6 POWER SOURCES FOR PERIPHERALS

The only peripheral units which are powered from the console are:

1) the remote handheld unit receiver
2) 4K x 8 RAM expansion
3) the speech unit.

All other peripherals have their own power lines to 110 volts AC. Power lines for all add-on options will be a comparable length, with that of the console itself.

3.2.7 KEYBOARD

The keyboard is a QWERTY with 50% stagger, in order to allow the maximum speed of data entry. It is a travel keyboard and does supply tactile feedback. Keytops are spaced on 0.75" x 0.75" centers. The keyboard is designed for the user to lay various

overlays in a recessed area. These overlays redefine the keys as needed for the Replay Calculator, Number Magic, and other software packages. For the customer who purchases the console, but no remote handheld units, an overlay is used to map two joysticks to the keyboard. (See Figure 3.2.B, Joystick/Console Mapping.)

3.2.8 SPEAKER

The Home Computer shall be capable of including a two-inch diameter 8 OHM speaker with independent volume control; however, the usual product configuration will utilize TV volume control and speaker.

3.2.9 INTERCONNECTS

Interconnect ports are designed into the console as shown in Figure 3.2.A to accommodate:

1) up to four peripherals or an expansion chassis with capabity for eight peripherals
2) either one or two cassette units--either manual or electronically controlled
3) port for Solid State Software (TM) module or library
4) remote HHU receiver
5) ear phone
6) four-pin power plug where voltages are brought from the wall transformer
7) external video input
8) standard NTSC composite video output
9) RF output
10) RAM expansions.

3.2.10 RESET

A push button reset switch is provided on the back of the console.

3.2.11 TELEVISION INTERCONNECT

The console shall be directly connected to the home TV antenna connector using a TV/computer selector switch supplied with the unit. The cable will be sixteen feet long with connectors on each end such that it can either be used to connect the RF port to a TV set, or the composite video output to a monitor. The RF output includes sound modulation with standard pre-emphasis.

3.2.12 FEDERAL COMMUNICATIONS COMMISSION APPROVAL

The console is a Class I TV device and must be type approved by the FCC.

3.2.13 VENTING

Venting is provided on the bottom, top, and on the back to cool the internal circuitry.

3.2 PHYSICAL REQUIREMENTS OF CONSOLE (continued)

3.2.14 VIDEO

The Home Computer shall be capable of generating the following list of colors:

1) white
2) gray
3) magenta
4) yellow 1
5) yellow 2
6) red 1
7) red 2
8) red 3
9) cyan
10) blue 1
11) blue 2
12) green 1
13) green 2
14) green 3
15) black
16) transparent

3.2.15 POWER-UP VIDEO

The H.C. powers-up and displays an introductory screen that identifies the product, shows color bars for TV set adjustment, and invites the user to press any key to begin. When a response is detected from either the console keyboard or a remote HHU, the screen is changed to contain a list of all available programs. Up to nine program titles may be listed on the screen and each has a single digit to identify it.

When a response is detected on the console or a remote HHU, the selected program is executed. If more than nine programs are available, the user may press any key not in the range 1-9 to scroll between menus. After the last page of a multi-page menu, the first page will be shown.

Whenever no response has been detected prior to selection of a program, the introductory screen is display for five minutes. The H.C. will then alternate between the introductory screen and the first page of the menu at 30-second intervals.

3.2.16 SOUND

Sound for the Home Computer shall be generated using a TIM 9919 chip. The frequency range for these sounds shall be between 109.25 Hz and 55.93 KHz. The unit shall be capable of generating three separate program tones plus a fourth tone for a random noise generator.

3.3 CONSOLE CIRCUITRY

3.3.1 CONSOLE BLOCK DIAGRAM

3.3 CONSOLE CIRCUITRY (continued)

Figure 3.3.A is a block diagram of the console. The major functional blocks as depicted are:

1) TMS 9985 - Microprocessor as the system control and processing element
   - 16 bit instruction word
   - Mini-computer instruction set including multiply and divide
   - 256 bytes of RAM on chip
   - 16 general register architecture
   - Can control or address up to 65536 bytes of memory
   - 8 bit memory data bus
   - Four prioritized interrupts
   - On chip timer
   - On chip 5 MHz oscillator
2) TMS 9918 - Video display processor to control display memory and generate composite video signal
   - Refresh the TV screen at 60 Hz without interlace for composite NTSC type video output
   - 24 lines of 32 characters with 8 x 8 dot resolution
   - 32 movable characters with magnification
   - 24 lines of 40 characters with 6 x 8 dot resolution
   - 48 lines of 64 independent spots
   - External video input with sync
   - Provides sixteen colors
   - Provides eight sets of color select registers to provide separate color for ones and zeros
   - Addresses 4-16K bytes of RAM for CPU or display
3) TMS 9919 - Sound controller chip to provide sound to system
   - Three voices with four octave musical resolution
   - 15 bit programmable noise shift
   - 100 MW audio drive with 30 db control in 2 db steps
   - I^2L Technology
4) TMC 0430 - 6K byte IC's in console to provide low cost P-channel ROM (3) The total 18 bytes of slow ROM in the console are allocated as follows:
   - 11.0K BASIC
   - 2.8K Monitor
   - 3.2K Number Magic
   - 1.0K Replay Calculator
5) TMS 4732 - Provides 8K bytes of fast N-channel ROM (2) Allocated as follows:
   - 2.5K Graphics Language Interpreter
   - 1.0K Device Service Routines
   - 1.5K Floating Point Package
   - 3.0K BASIC Support Package
6) TMS 4027 - Provides 4K bytes for fast Graphics RAM
7) TMS 9901 - I/O controller for communications

ppm failures

3.4 CONSOLE SOFTWARE

3.4.1 SYSTEMS SOFTWARE

The Home Computer mainframe includes systems software and applications programs. The software is stored in ROM so it is available when the user turns on the computer.

The system software includes a monitor, a Graphics Language Interpreter and a BASIC Interpreter. The Graphics Language Interpreter is written in the language of the 9985 microprocessor while BASIC and the monitor are written in both 9985 code and the Graphics Language. The fast ROM in the system contains the 9985 programs and the slower but less expensive GROMs contain numerically encoded Graphics Language. The Graphics Language was developed to allow use of these GROMs and to facilitate easy access to the graphics capabilities of the TV screen.

When the system is turned on the monitor initializes the display to contain a menu of available programs. The menu includes the BASIC interpreter and the applications programs built into the mainframe and also any programs plugged into a module slot. When the user selects a program, the monitor passes the starting address of the program to the Graphics Language Interpreter. The monitor remains active in the background and performs timekeeping and input/output functions during program execution.

The BASIC Interpreter allows the user to program the Home Computer to solve problems. BASIC is an interactive language that includes algebraic and logical operations. The BASIC implemented on the Home Computer complies with the definition of ANSI Minimal BASIC and has been extended to include special graphics and sound operations. In addition, BASIC complies with the TI Standard BASIC for upward compatibility. The user enters and edits his program with the typewriter-style keyboard and can store it for later use on audio tape cassettes or the ADD disk or magnetic bubble when available.

3.4.2 APPLICATIONS PROGRAMS

The applications built into the mainframe include a Number Magic education program similar to the Little Professor and a Replay Calculator similar to the TI-1680 with the ability to scroll the 'tape' and replace erroneous entries anywhere in the middle of the calculation.

3.4.3 LIST OF GRAPHICS LANGUAGE INSTRUCTIONS

The Graphics Language was developed here at TI specifically for the Home Computer. The Graphics Language Instruction Set is outlined in Figure 3.4.A.

4.0 PERIPHERAL PRODUCT SPECIFICATION

4.1 HANDHELD TRANSMITTER, RECEIVER, AND CRADLE

4.1.1 HANDHELD TRANSMITTER

- Dimensions: 6.0" x 3.3" x 1.1"

4.1 HANDHELD TRANSMITTER, RECEIVER, AND CRADLE (continued)

- High resolution joystick on top; 225 positions
- 5 x 4-key keyboard; compatible with user changeable overlays
- Metal overlay on top and front
- In right middle of unit top is a three position On/Off switch, spring loaded to center position, and an LED power on indicator
- In the left middle of unit is a four position switch for user to specify the unit
- Automatic power off after five minutes is included
- Standard power source is 9 volt battery; BP-8 rechargeable 8 volt battery pack is an option
- Battery life for 9 volt cell is 25 hours of use; BP-8 rechargeable 8 volt battery pack life is 5 hours
- Battery is inserted in bottom of unit
- One IR emitter is at each side of front of unit
- Response time to either keypress or joystick is approximately 0.1 seconds (assuming two transmitters working)
- Odd parity, 12 bit data transmission
- IR emitters active only when new information is transmitted
- Horizontal angle with respect to received is $\pm 30^{o}$
- Vertical angle $\pm 15^{o}$
- Distance up to approximately fifteen feet; distance ratio between closest and farthest unit can be 1:5

4.1.2 HHU RECEIVER

- Dimensions: 6.85" x 2.5" x 1.15"
- Attaches to top of console with 12 pin connector
- Front of unit has plastic lens/filter in front of detector diode
- Capable of accepting one to four frequency multiplexed transmitters
- Horizontal angle is $\pm 60^{o}$
- Has channel number check as well as parity check
- Powered with $\pm$ 5 volts and + 12 volts from console supply
- Interrupts mainframe CPU only when it detects new information
- Data transmission time for 12 bit word from receiver to console CPU is not more than 0.5 milliseconds

4.1.3 HHU CRADLE

A cradle is provided so that two HHU's can be inserted in the cradle to serve as a remote keyboard. One overlay is provided to cover the units in the cradle. This overlay is similar to the console keyboard without stagger. Provision for plugs on the cradle have been made so HHU's can be recharged with AC 9132 charger/plug while they sit in the cradle.

4.2 PRIVATE LABEL CASSETTE UNIT

- Dimensions: 5.6" x 10.25" x 2.8"

4.2 PRIVATE LABEL CASSETTE UNIT (continued)

- Standard cassette unit powered either from batteries or 120 volt AC
- Digital tape counter
- Hand microphone and earphone not included
- Eject key plus five manual controls: play, record, fast forward, reverse, and stop
- Manual volume and tone control
- Automatic level control (AVC)
- Frequency response: 100 Hz - 5 MHz; S/N 26 db
- Erasing efficiency: 60 db at 1 KHz
- Microphone jack, earphone jack, and remote jack
- Microphone jack defeats any built-in microphone
- Adaptors are supplied for all possible remote jack polarity configurations
- Comes with cable for single cassette operation
- "Y" cable for dual cassette operation available as an option
- UL and CSA approved
- 1 7/8" tape speed with capstan drive; $\pm$ 3% speed tolerance
- Recommend C60 tape; 30 minutes on each side
- Total storage capacity for C60 tape: 540K bytes
- Comes with instruction manual, tape, single cable with adapters, 110 volt cord
- Electronic pause control

4.3 GROM MODULE SPECIFICATION

- Dimensions: 4.2" x 2.8" x 0.9"
- Three piece plastic case containing one PC board
- May contain up to five TMC 0430 GROM chips, or may contain four GROMs and one TMS 4732 fast ROM
- The five GROM chips could contain 30K bytes of program coded in Graphics Language
- Title and description of application is on module label
- Complete with instruction manual and any keyboard overlays necessary for either console keyboard or HHU use

4.4 4K x 8 RAM EXPANSION SPECIFICATION

- Dimensions: 5.9" x 1.9" x 0.6"
- Board will be enclosed by a metal cover and heat sinking will be provided
- Customer removes cover on back of console and RAM expansion plugs onto console circuit board
- Power is supplied from console
- Address decoding and RAM select is performed by the TMS 9918 VDP which can select one of four 4K byte RAM blocks. Block #1 is built into the console; the module is block #2
- Comes with instruction manual

4.5 16K x 8 RAM EXPANSION SPECIFICATION

- Dimensions: 5.9" x 1.9" x 0.6"
- Board will be enclosed by a metal cover and heat sinking will be provided
- Customer removes cover on back of console and RAM expansion plugs onto console circuit board
- Power is supplied from console
- Address decoding and RAM select is performed by the TMS 9918 VDP which can select one of four 4K byte RAM blocks. Block built into the console is disabled; the module contains all four blocks
- Comes with instruction manual

SIZE		DRAWING NO.
A		
SCALE	REV	SHEET 12

5.0 PLANNING FOR INTRODUCTION OF VARIOUS SYSTEM PRODUCTS

5.1 4Q78 SOFTWARE AND PERIPHERALS

HARDWARE ITEM	ADDITIONAL CAPABILITY
Mainframe	-----
Remote Keyboards	Joysticks and Wireless Convenience
Cassette	Nonvolatile Storage
Memory Options	4K RAM Expansion
Synthetic Speech Module	Speech and Advanced Sounds

SOFTWARE PROGRAMS

Tax & Financial
Grammar & Reading
Health & Nutrition
Chess Master
Preschool Shapes, Colors, Letters, Numbers
Football
Investment Planning
Interactive Basic Tutor
Space Wars/Star Trek
Color Art
Diagnostic GROM

5.2 1Q79 SOFTWARE AND PERIPHERALS

HARDWARE ITEM	ADDITIONAL CAPABILITY
Thermal Printer	Hard Copy Output
Digitally Controlled Cassette	Computer Control of Cassette

SOFTWARE PROGRAMS

Spanish Language
Spelling Bee
Audio Visual Aids for Handicapped
Sign Language Tutor
Economics Simulation (Hammurabi)
Preschool Words & Sounds
Music Tutor
Video Tinkertoys
Go/Reversi Master
Backgammon Master

5.3 2Q79 SOFTWARE AND PERIPHERALS

HARDWARE ITEM	ADDITIONAL CAPABILITY
MODEM/DAA	Data Telecommunications
Home Security/Control Unit	Sensing and Actuation
Module Library	Storage and Software Selection of 8 GROMS

5.3 2Q79 SOFTWARE AND PERIPHERALS (continued)

SOFTWARE PROGRAMS

Personal Electronic Mail
Home Security
Typing Tutor
Home Energy Analysis
Business Simulation
Phonics Tutor
French Language
Bridge Master
Algebra Tutor
Wumpus

5.4 3Q79 SOFTWARE AND PERIPHERALS

HARDWARE ITEM	ADDITIONAL CAPABILITY
ADD Disk	Rapid Mass Storage
Expansion Chassis	Expansion up to eight peripherals per console

SOFTWARE PROGRAMS

Menu Storage, Planning, Scaling
Pantry Inventory & Shopping List
Geometry Tutor
Personal Calendar & Records
German Language
Home Data Terminal
Automatic Telephone Answering & Dialing
Wall Street Simulation/Analysis
Color Organ
Civil War Simulation

5.5 4Q79 SOFTWARE AND PERIPHERALS

HARDWARE ITEM	ADDITIONAL CAPABILITY
Control Actuators	Appliance and Climate Control
Typewriter	Text Editing with Student-Quality Output
Checkwriter	Semi-automatic Monthly Bill Paying

SOFTWARE PROGRAMS

Home Control
Japanese Language
Trigonometry Tutor
Chess Openings Tutor
Electronic Dictionary

5.5 4Q79 SOFTWARE AND PERIPHERALS (continued)

Physics Tutor
Student Text Editing System
Dancing Marionettes
Blackjack/Poker
Concentration

6.0 DOCUMENTATION

Documentation for the console will include but not be limited to the following:

- User operating manual with troubleshooting and repair section
- User Programming Manual
- Overlays for Replay Calculator and Number Magic

Documentation for the software modules will include but not be limited to the following:

- User Operating Manual
- Overlays necessary for keyboard or HHU operation

Documentation for each peripheral will include but not be limited to the following:

- User Operating Manual with troubleshooting and repair section

7.0 SHIPPING TESTS, ENVIRONMENTAL, AND RELIABILITY

7.1 VIBRATION IN SHIPPING CONTAINER

- QRAs 10237 Para 11.A., Mil Std-810B, method 514-1, procedure X per Para 4.5.1.3, test curve AY
- 3.5G sinusoidal
- 5-200-5 Hz
- 15 min per axis

7.2 TRANSIT DROP IN SHIPPING CONTAINER

- QRAs 10237 Para 11.C, except 48" height
- 48" drop six times (one side, bottom, two corners, two edges of carton)

7.3 RANDOM VIBRATION IN SHIPPING CONTAINER

- Mil Std - 810B Table 514.I-V procedure V with 10G random vibration envelope modified as follows: 12 db/octave rise from 20 Hz and 24 db/octave fall from 500 Hz QRAs 10237 Para 11.D
- 10G RMS 20-50 Hz
- Random Vibration
- 30 min/plane

7.4 LOOSE CARGO BOUNCE IN SHIPPING CONTAINER

- QRAs 10237 Para 11.B, Mil Std-810B, method 514.1, procedure XI. Para 4.16.2, 4.16.2.3 and 4.16.2.41DA.

7.4 LOOSE CARGO BOUNCE IN SHIPPING CONTAINER (continued)

- 24 Hz sinusoidal
- .1DA, 3 hours (1/2 hour per side)

7.5 DROP SHOCK

- 10 inch drop on top, bottom, and four sides of each unit

7.6 TEMPERATURE EXTREME (OPERATING)

- QRAs 10237 Para 11.E (45°C) - four hour temperature soak with power up for 1/2 hour after soak. Return to room temperature and power up.
- QRAs 10237 Para 11.F (10°C) - same as above

7.7 TEMPERATURE CYCLE (OPERATING)

- QRAs 10237 Para 11.G - except temp shall be +10°C to +45°C
- Five cycles from +10°C to +45°C; one hour at temp extremes and 1/2 hour at 25°C between temperature excursions

7.8 STORAGE - HIGH TEMPERATURE

- QRAs 10237 Para 11.I - 70°C
- Sample size - five units
- 1000 hour storage at 70°C, RH 20%
- Power up at room temperature after 168, 500, and 1000 hours

7.9 STORAGE - LOW TEMPERATURE

- QRAs 10237 Para 11.J - -40°C
- Sample size - five units
- 1000 hour storage at -40°C, RH 60%
- Power up at room temperature after 168, 500, and 1000 hours

7.10 STORAGE - HIGH HUMIDITY

- QRAs 10237 Para 11.K
- Sample size - five units
- 360 hour storage at 35°C, RH 85%
- Verify operation after room temperature stabilization

7.11 ELECTROMAGNETIC SUSCEPTIBILITY

- Mil-Std 461, 462
- Conducted susceptibility
- CS01, CS02, CS06
- Radiated susceptibility
- RS01, RS02, RS03

7.12 INTERMITTENT OPERATION

- QRAs 10237 Para 11.H
- Power cycle one hour on, one hour off for 500 cycles at 35°C, RH 85%
- Three subgroups of five units: operate at 105 volts, 117 volts, and 130 volts respectively

7.13 RELIABILITY

The reliability of the system shall be based on five hours per day of operation, seven days per week, 365 days per year. The meantime between failure (MTBF) shall be in excess of five years (43.8 x 103 hours).

8.0 SUMMARY

This document describes from a functional standpoint the major features planned for the Home Computer system. The design requirements include the following:

1) Solid State Software (TM) and peripheral interfaces for expanded system hardware configurations
2) System software with hooks for planned system expansion
3) User interface for "easy" problem solving
4) Compatibility with Milton Bradley software modules
5) Compatibility with the SR-62

The Home Computer will be a mass marketed true consumer computer. The product has three main thrusts: information, education, and entertainment. This requires that the product be fully supported with a broad line of peripherals and a comprehensive selection of Solid State Software (TM) modules. The personal Computer Strategy requires timely announcement and entry of products to acquire distribution channels and gain market share. The Home Computer development plan is currently designed for 1Q79 product introduction with high technological risk and moderate schedule risk.

APPENDIX A

SYSTEM INTERFACE DETAILS

SIZE		DRAWING NO.
A		
SCALE	REV	SHEET 18

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GROM CONNECTOR

SIGNAL	PIN	I/O	DESCRIPTION
GND	1		System Ground
	2		
	35		
GND	36		
I/O 0	3	I/O	Buffered Data BUS I/O 0 is the MSB of the 8
1	5	I/O	bit data bus and I/O 7 is the LSB. The data
2	7	I/O	bus is disabled for $\overline{Ad0}$·Ad1·$\overline{Ad2}$ or Ad0·$\overline{Ad}$·Ad2
3	9	I/O	to allow VDP and 4732 operations
4	11	I/O	
5	13	I/O	
6	15	I/O	
I/O 7	17	I/O	
VSS	19		+5 volts initiates each of 3 commands for 0430
$\overline{\text{GROM SEL}}$	21	OUT	Active low select from 74LS138 (Ad0 Ad1 $\overline{Ad2}$ $\overline{\text{MEMEN}}$
DBIN	23	OUT	Data Bus In when active (HIGH) the data buffer and 9985 are in input mode. Also MODE 0 for 0430 selecting input and output.
Ad 14	25	OUT	Address bit 14 also serves as MODE 1 for 0430 selecting address (high) or data (low).
GROM CLOCK	27	OUT	445KHz oscillator for the 0430
Vbb	29		-5 Volts
GROM R	31	IN	GROM READY normally LOW released to pull up when READY
Ad3	33	OUT	Address bit 3
CRU CLK	4	OUT	CRU CLOCK. When active (High) external device addressed by Ad0-Ad14 should sample CRU OUT/Ad15
CRU IN	6	IN	CRU DATA IN is the input data for CRU input selected by Ad0-Ad14
Ad15/CRU OUT	8	OUT	Address bit 15 is also used for CRU Output addressed by Ad0-Ad14
Ad13	10	OUT	16 bit buffered address bus Ad0 is MSB and AD15
12	12		the LSB
11	14		
10	16		
9	18		
8	20		
7	22		
6	26		
5	28		
4	30	OUT	
+12	24		+12 Volts
$\overline{\text{WE}}$	32	OUT	Write enable signals write function from 9985 to memory active (LOW)
R/R SET	34	OUT	ROM/RAM select is an active (LOW) memory block enable ($\overline{A0}$ A1 A2)

RAM EXPANSION CONNECTOR

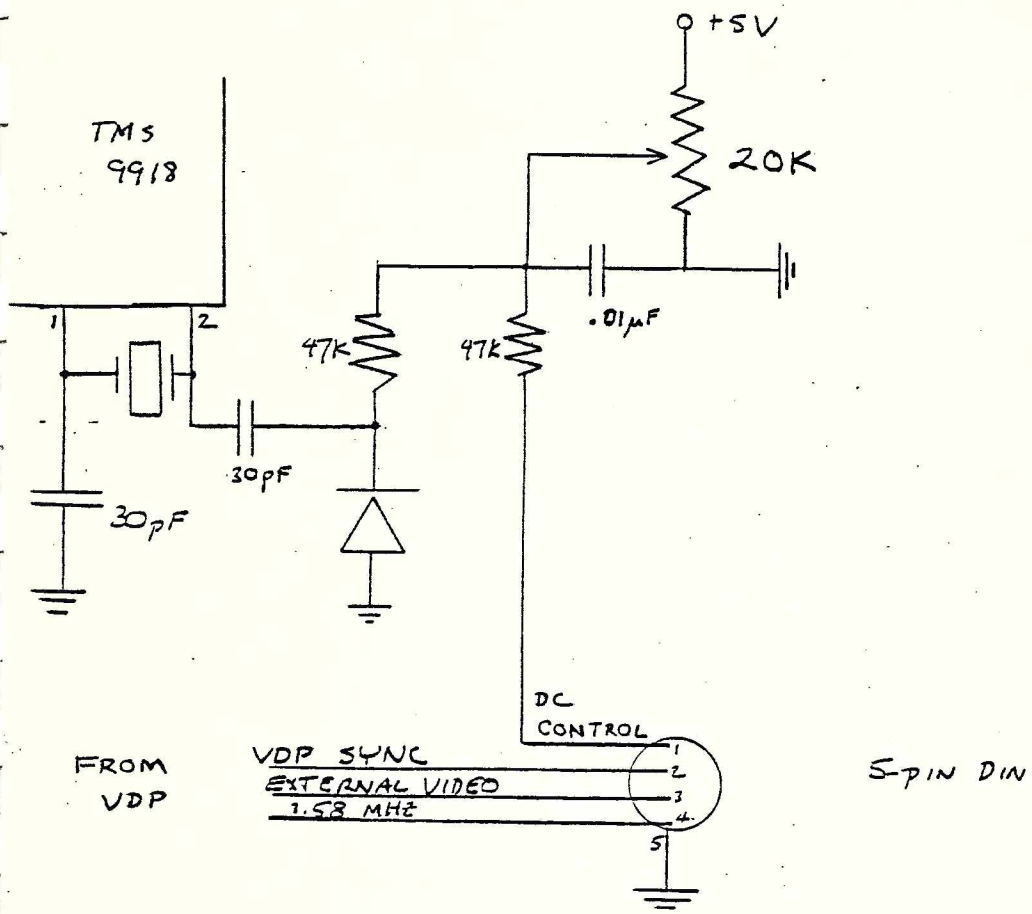
SIGNAL	PIN	I/O	FUNCTION
S	1	IN	Memory select for first 4K, pull up resistors selects first 4K if memory expansion not used
IDO	8	IN	8 bit data input bus to 9918
1	12	IN	IDO is MSB and ID7 is LSB
2	16	IN	
3	22	IN	
4	2	IN	
5	3	IN	
6	15	IN	
7	20	IN	
AO/D7	14	OUT	8 bit data output and 7 bit address bus
A1/D6	19	OUT	AO/D7 LSB DO MSB RAS and CAS
A2/D5	18	OUT	form a 14 bit address.
A3/D4	17	OUT	
A4/D3	21	OUT	
A6/D2	23	OUT	
A6/D1	9	OUT	A6 is memory b and select
/DO	5	OUT	
RAS	7	OUT	Row address strobe active (low) edge clocks row address for dynamics RAM
CAS	13	OUT	Column address strobe active(low) edge clocks Columns address for dynamic RAM
W	6	OUT	Write enable to write to RAM
Vcc	11		+5 Volts
VBB	4		-5 Volts
VDD	10		+12 Volts
GND	24		System Ground

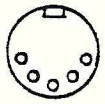
I/O CONNECTOR

SIGNAL	PIN	I/O	DESCRIPTION
GND	1		System
GND	2		Ground
GND	43		
GND	44		
I/O 0	3	I/O	Buffered Data Bus I/O o is the MSB of the 8 bit
I/O 1	5	I/O	Data Bus and I/07 is the LSB. The data bus is
I/O 2	7	I/O	disabled for $\overline{\text{Ad 0}}$·$\overline{\text{Ad 1}}$·Ad 2 or Ad 0·$\overline{\text{Ad 1}}$·Ad 2
I/O 3	9	I/O	to allow VDP and 4732 operation
I/O 4	11	I/O	
I/O 5	13	I/O	
I/O 6	15	I/O	
I/O 7	17	I/O	
VSS	19		+5 volts
Sound in	21	IN	Input to summing junction of sound chip through 200 Ω
DBIN	23	OUT	Data Bus IN. When active (high) the data buffer and 9985 are in input mode. DBIN is also MODE0 for the 9918, 9919, and 0430
T	27	OUT	2.5MHz clock output signal from 9985
Vbb	29		-5 volts
RDY/HLO	31	IN	System Ready. Cut collector drive. Active low during $\overline{\text{MEMEN}}$ will stop 9985 until signal is taken high. When MEMEN is not active ready low will hold 9985 at end of instruction
HOLDA/1A0	41	OUT	Hold A knowledge 1 instruction acknowledge when $\overline{\text{MEMEN}}$ is active. 1HQ is active (high) otherwise it acknowledges a hold with active (high).
CRU CLK	4	OUT	CRU CLOCK. When active (high) external device addressed by AD0-AD14 should sample CRU OUT/AD15
CRUIN	6	IN	CRU DATA IN is the input data for CRU input selected by AD0-AD14
AD0	39	OUT	Buffered CPU 16 bit address bus AD0 is MSB
AD1	37		and AD15 LSB
AD2	35		
AD4	30		
AD5	28		
AD6	26		
AD7	22		
AD8	20		
AD9	18		
AD10	16		
AD11	14	OUT	
AD12	12	OUT	
AD13	10	OUT	
AD14	25	OUT	
AD15/CRU OUT	8	OUT	Address bit 15 is used for CRU OUTPUT on CRU OUTPUT instructions AD0-AD14 select up to 321 devices

INTL	24	IN	Interrupt INT1 to 9901 active (low). All external interrupts fan into this point. It has 1 OK pull up resistor.
WE	32	OUT	Write enable signals write function from 9985 to memory active (low).
MBE	34	OUT	Memory block enable $\overline{AD0}$ $\overline{AD1}$ AD2 active (low).
MEMEN	36	OUT	Memory enable active low indicates the bus contain an external memory address.
I/O CONTROL	38	I/O	CRU line _____ from 9901 true logic
RESET	40	IN	Reset active (low) (Schmitt Trigger) A non markable interrupt trap to 000. Input must be held active for a minimum of 5 clock cycles.
LOAD	42	IN	Load active (low) A non markable interrupt trap to EFFC.

VIDEO PERIPHERAL CONNECTOR





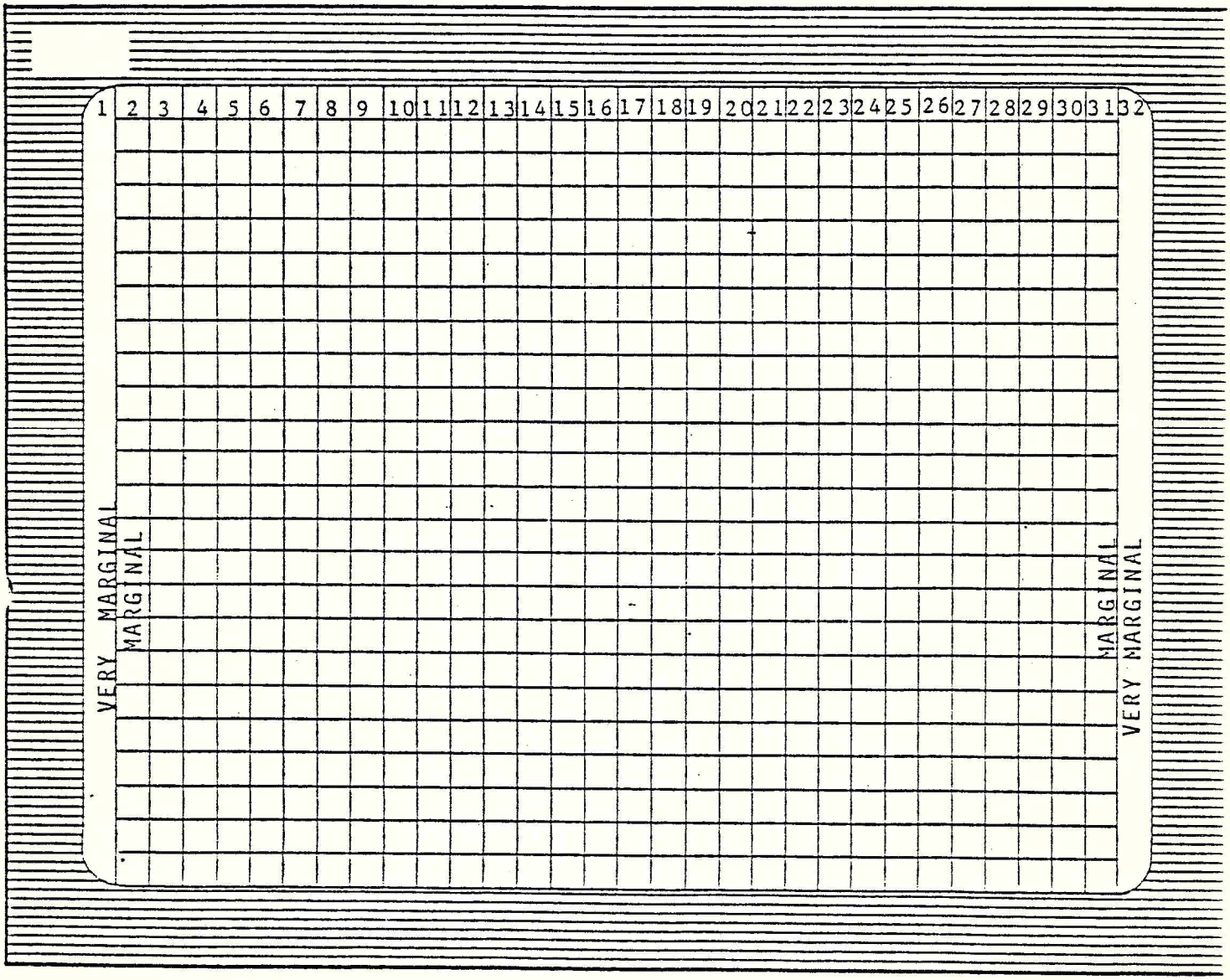
VDP COLORS May 16, 1978

(NOMINAL VALUES BASED ON CURRENT ENGINEERING ESTIMATES)

INPUT	COLOR	LUMINANCE*	CHROMINANCE* (Peak-Peak)	PHASE (Degrees)
N/A	BURST	0.0	.40	0 (ref.)
F	WHITE	1.0 (reference)	-	-
E	GRAY	0.80	-	-
D	MAGENTA	0.60	0.47	125
C	GREEN 3	0.47	0.60	305
B	YELLOW 1	1.00	0.40	10-15**
A	YELLOW 2	0.87	0.53	10-15**
9	RED 1	0.80	0.73	65
8	RED 2	0.67	0.73	65
7	CYAN	0.80	0.73	245
6	RED 3	0.53	0.53	65
5	BLUE 1	0.67	0.60	185
4	BLUE 2	0.47	0.73	185
3	GREEN 1	0.80	0.53	305
2	GREEN 2	0.60	0.60	305
1	BLACK	0.0 (reference)	-	-
0	TRANSPARENT	0.0	-	-

*Luminance and Chrominance levels based on White = 1.0 and Black = 0.0

**Yellow will be adjusted to more closely approximate the NTSC standard. The actual value will not be determined until actual parts are characterized.



VIDEO/COPY:

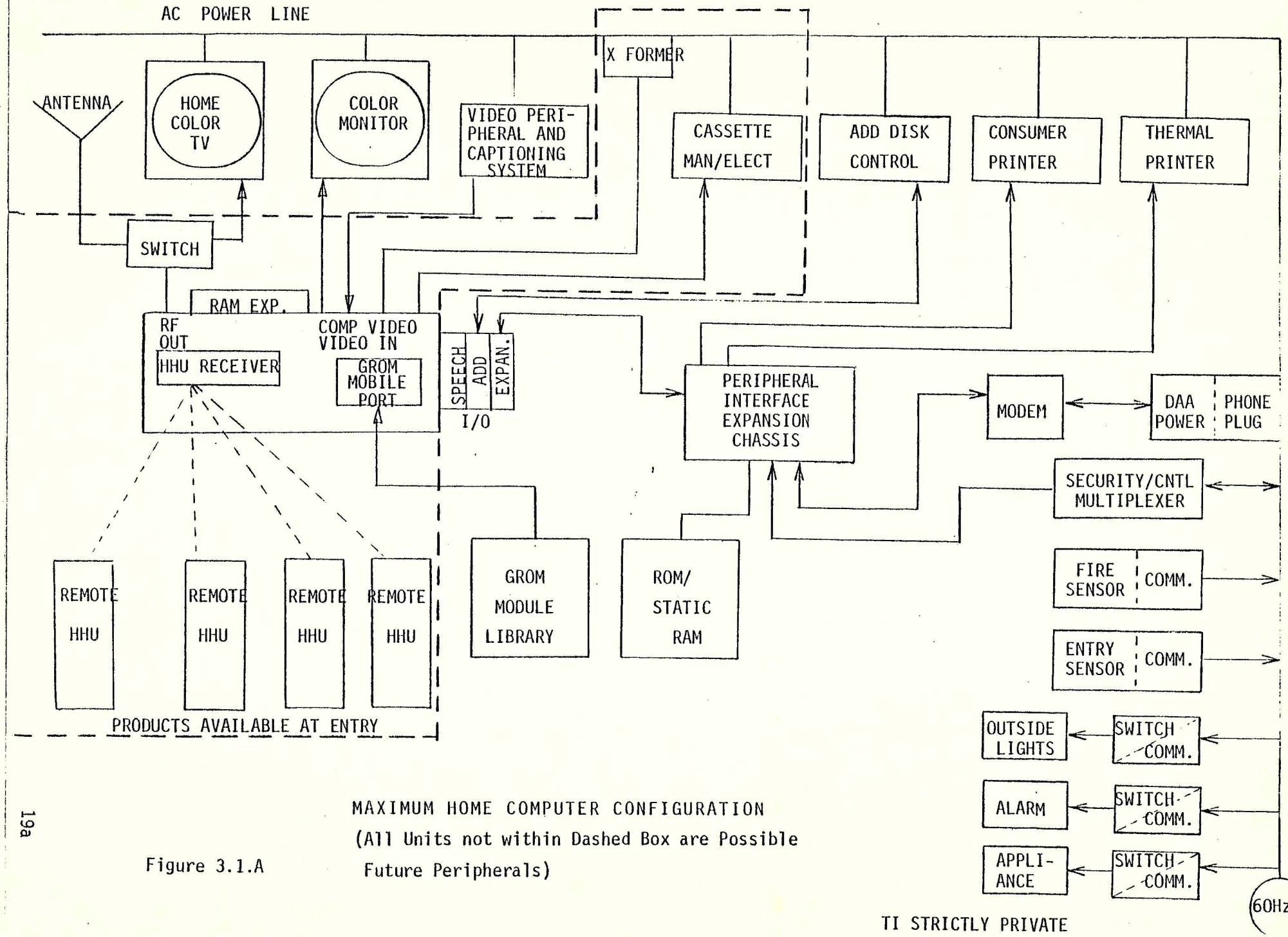
AUDIO/TONES:

APPENDIX B

FIGURES

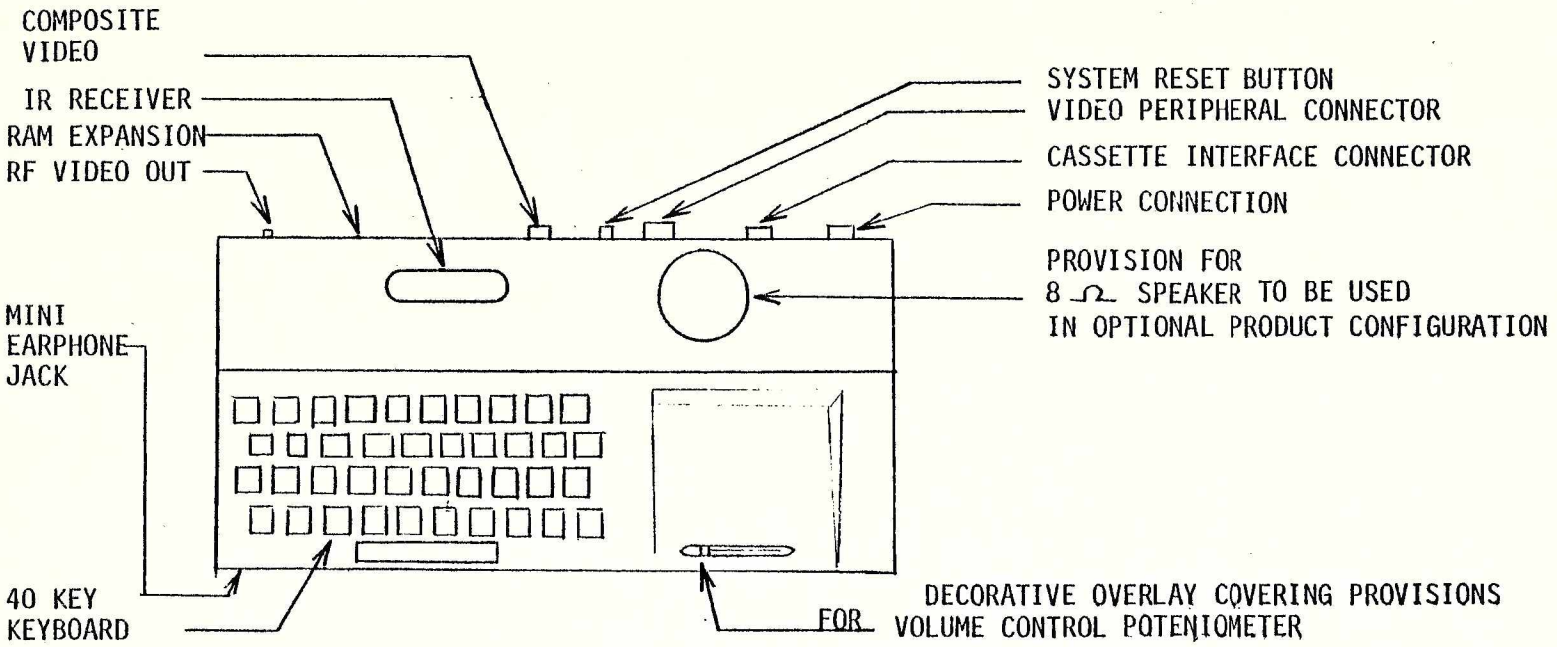
SIZE		DRAWING NO.
A		
SCALE	REV	SHEET 19

TI-22222

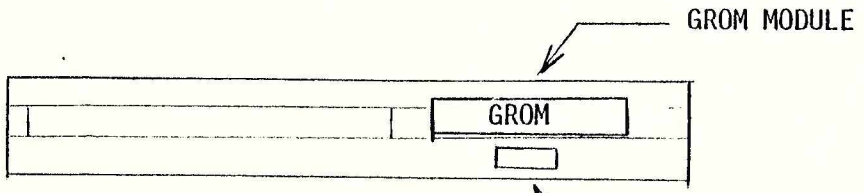


MAXIMUM HOME COMPUTER CONFIGURATION
(All Units not within Dashed Box are Possible Future Peripherals)

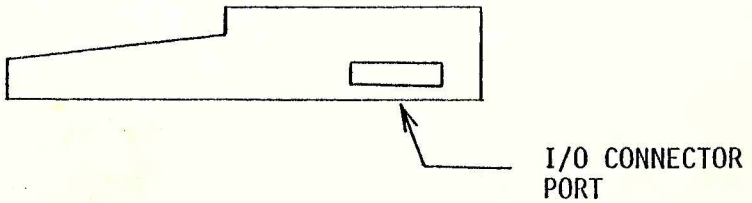
Figure 3.1.A



TOP VIEW

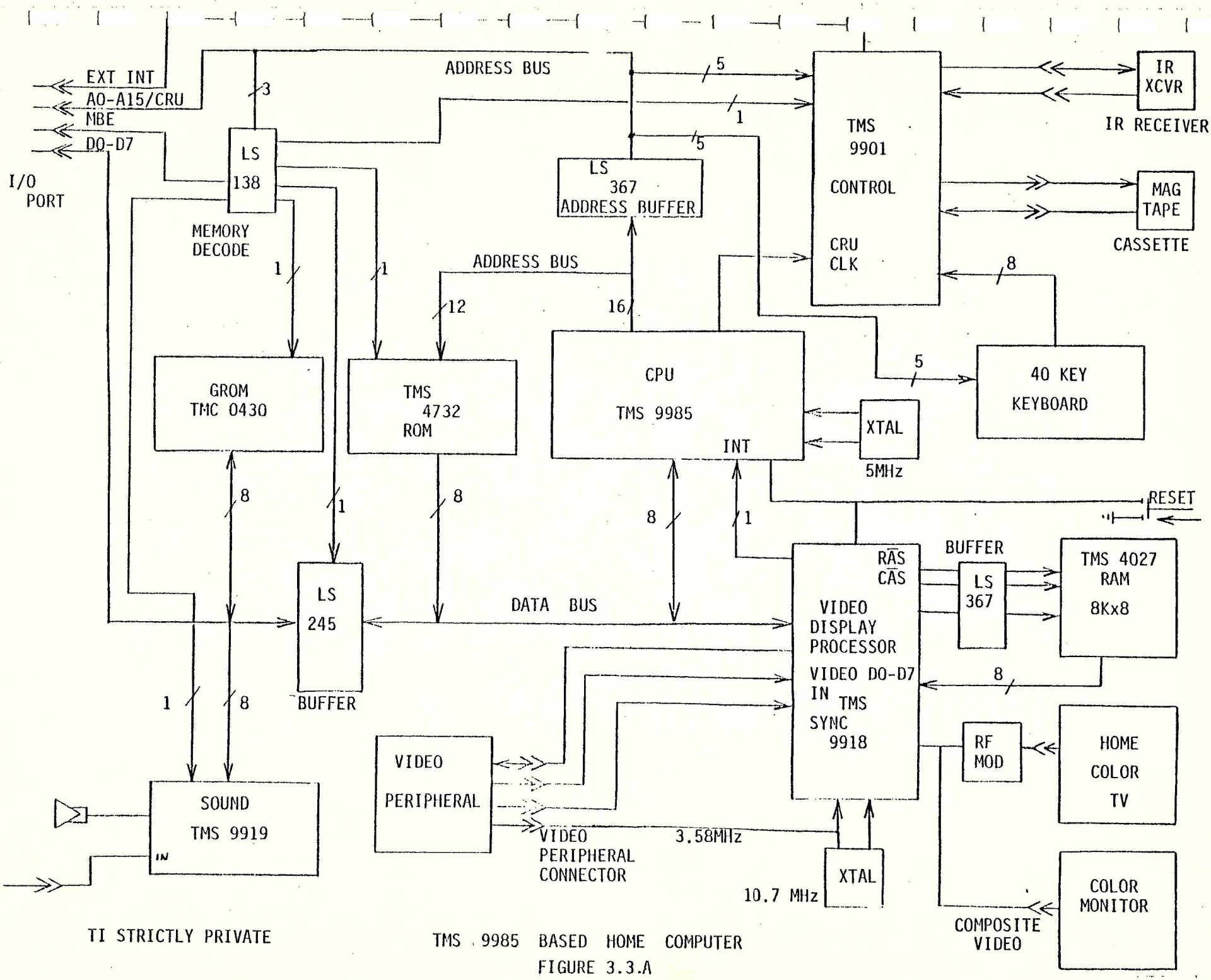


FRONT VIEW



SIDE VIEW

Figure 3.2.A.



TI STRICTLY PRIVATE

TMS 9985 BASED HOME COMPUTER

FIGURE 3.3.A

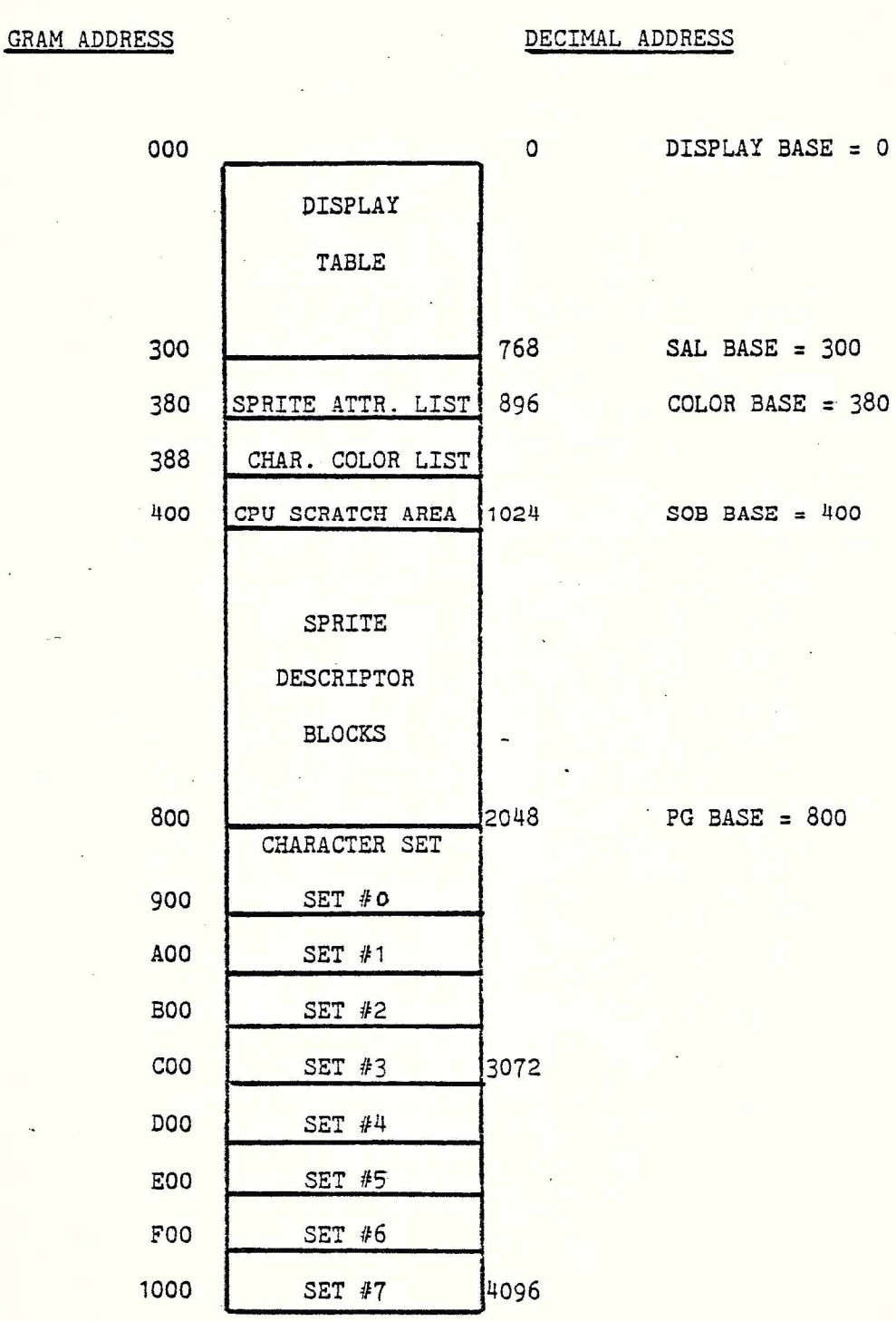
Figure 7.5

FIGURE 3.4.A

GRAPHICS LANGUAGE INSTRUCTION SET

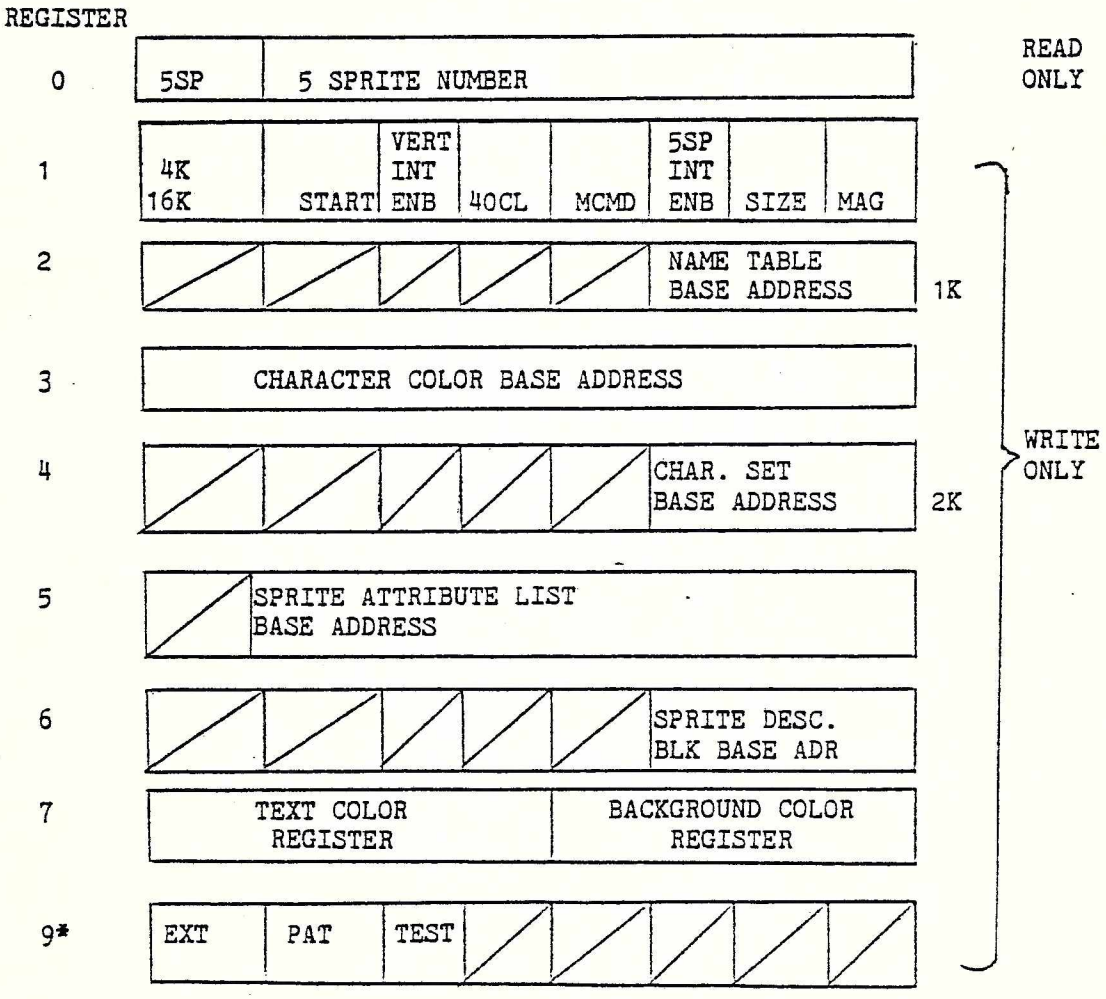
MNEMONIC	OPCODE	FORMAT	STATUS AFFECTED	INSTRUCTION
ABS	80	6	NONE	ABSOLUTE VALUE
ADD	A0	1	ALL	ADD
ALL	07	2	NONE	LOAD SCREEN
AND	B0	1	ALL	AND
B	05	3	COND	BRANCH$HARD)
BACK	04	2	NONE	LOAD BORDER
BR	40	4	COND	BRANCH ON RESET$SOFT
BS	60	4	COND	BRANCH ON SET$SOFT
CALL	06	3	COND	CALL SUBROUTINE
CARRY	0C	5	COND	CARRY STATUS TO COND
CASE	8A	6	COND	CASE
CEQ	D4	1	COND	COMPARE EQUAL
CGE	D0	1	COND	COMPARE GREATER OR EQUAL
CGT	CC	1	COND	COMPARE GREATER
CH	C4	1	COND	COMPARE HIGH
CHE	C8	1	COND	COMPARE HIGH OR EQUAL
CLOG	D8	1	COND	COMPARE LOGICAL
CLR	86	6	COND	CLEAR
CZ	8E	6	COND	COMPARE TO ZERO
DEC	92	6	ALL	DECREMENT BY ONE
DECT	96	6	ALL	DECREMENT BY TWO
DIV	AC	1	ALL	DIVIDE
EXCH	C0	1	NONE	EXCHANGE
EXIT	12	5	NONE	EXIT
FETCH	88	6	NONE	FETCH
FMT	08	7	-	FORMAT COMMANDS FOLLOW
GT	0A	5	COND	GREATER STATUS TO COND
H	09	5	COND	HIGH STATUS TO COND
INC	90	6	ALL	INCREMENT BY ONE
INCT	94	6	ALL	INCREMENT BY TWO
I/O	0B	8	NONE	SPECIAL I/O
INV	84	6	NONE	INVERT$ONE'S COMPLEMENT)
MOVE	20	10	NONE	MOVE
MUL	A8	1	NONE	MULTIPLY
NEG	82	6	NONE	NEGATE$TWO'S COMPLEMENT)
OR	B4	1	ALL	OR
OVF	0D	5	COND	OVERFLOW STATUS TO COND
PUSH	8C	6	NONE	PUSH
RAND	02	5	NONE	RANDOM NUMBER
RTN	00	5	NONE	RETURN FROM SUBROUTINE
RTNC	01	5	COND	RETURN FROM SUBROUTINE STATUS INTACT
SCAN	03	5	COND	SCAN KEYBOARD
SLL	E0	1+	NONE	SHIFT LEFT LOGICAL
SRA	DC	1+	NONE	SHIFT RIGHT ARITHMETIC
SRC	E8	1+	NONE	SHIFT RIGHT CIRCULAR
SRL	E4	1+	NONE	SHIFT RIGHT LOGICAL
ST	BC	1	NONE	STORE
SUB	A4	1	ALL	SUBTRACT
XML	0F	9	NONE	---
XOR	B8	1	ALL	EXCLUSIVE OR

EXAMPLE MEMORY ORGANIZATION



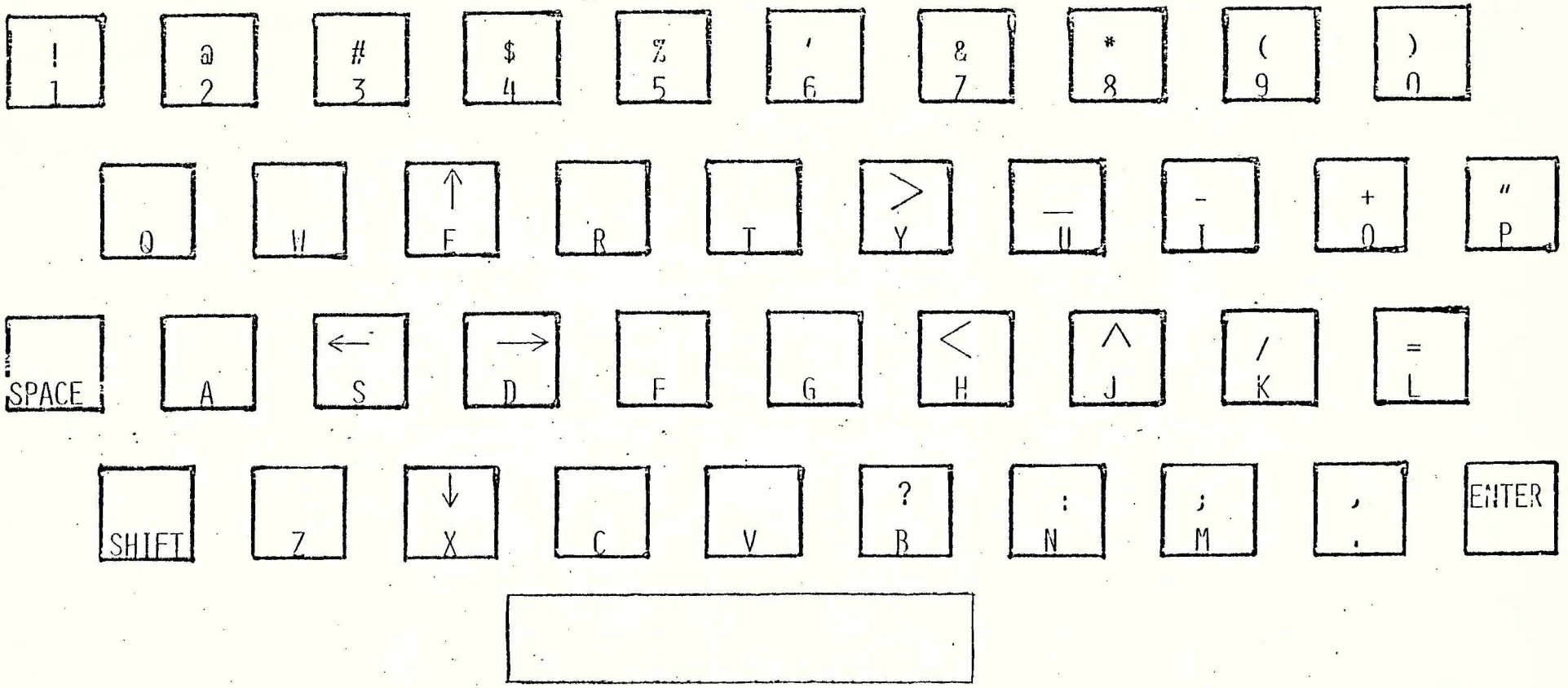
VDP REGISTER ASSIGNMENT

The video display chip has eight addressable registers to allocate RAM address spaces.

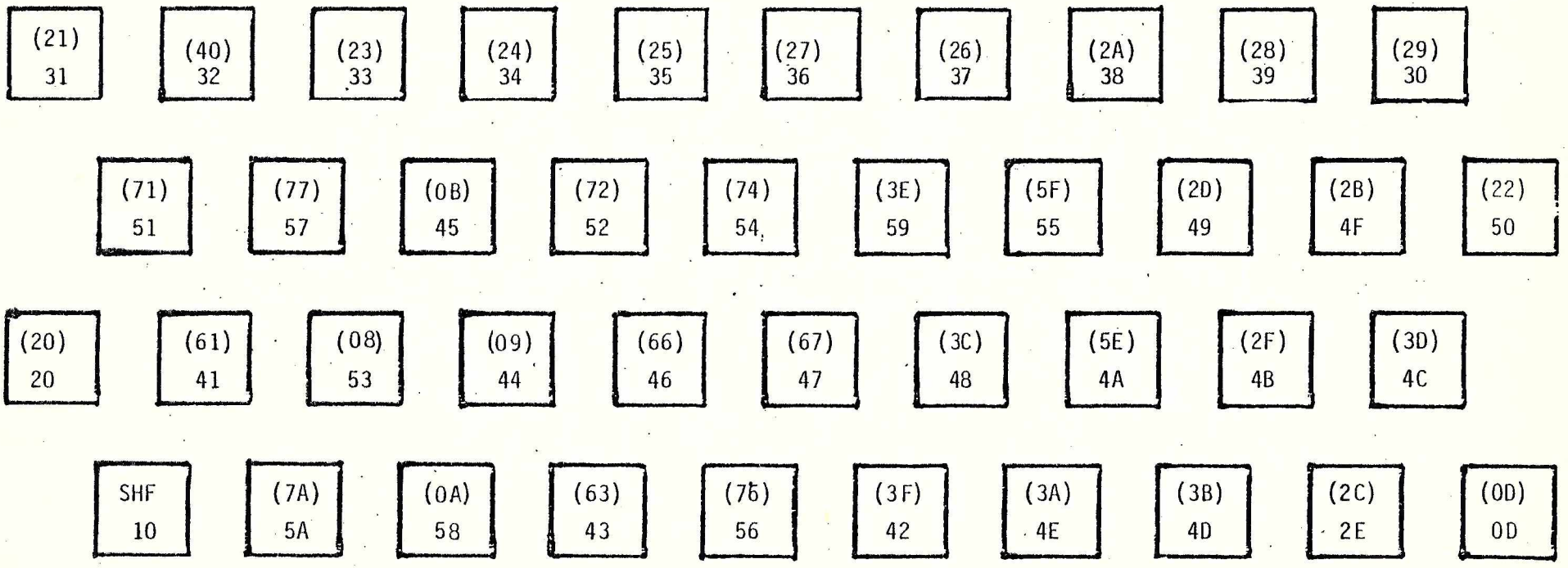


* Register #8 is not implemented.

CONSOLE KEYBOARD



CONSOLER KEYBOARD HEXDECIMAL-CODE ASSIGNMENTS



ASCII CODES

HEX/CHAR	HEX/CHAR	HEX/CHAR	HEX/CHAR	HEX/CHAR	HEX/CHAR
20 SP	30 0	40 @	50 P	60 `	70 p
21 !	31 1	41 A	51 Q	51 a	71 q
22 "	32 2	42 B	52 R	62 b	72 r
23 #	33 3	43 C	53 S	63 c	73 s
24 $	34 4	44 D	54 T	64 d	74 t
25 %	35 5	45 E	55 U	65 e	75 u
26 &	36 6	46 F	56 V	66 f	76 v
27 '	37 7	47 G	57 W	67 g	77 w
28 (	38 8	48 H	58 X	68 h	78 x
29)	39 9	49 I	59 Y	69 i	79 y
2A *	3A :	4A J	5A Z	6A j	7A z
2B +	3B ;	4B K	5B [	6B k	7B {
2C ,	3C <	4C L	5C \	6C l	7C |
2D -	3D =	4D M	5D]	6D m	7D }
2E .	3E >	4E N	5E ^	6E n	7E ~
2F /	3F ?	4F O	5F _	6F o	7F Del

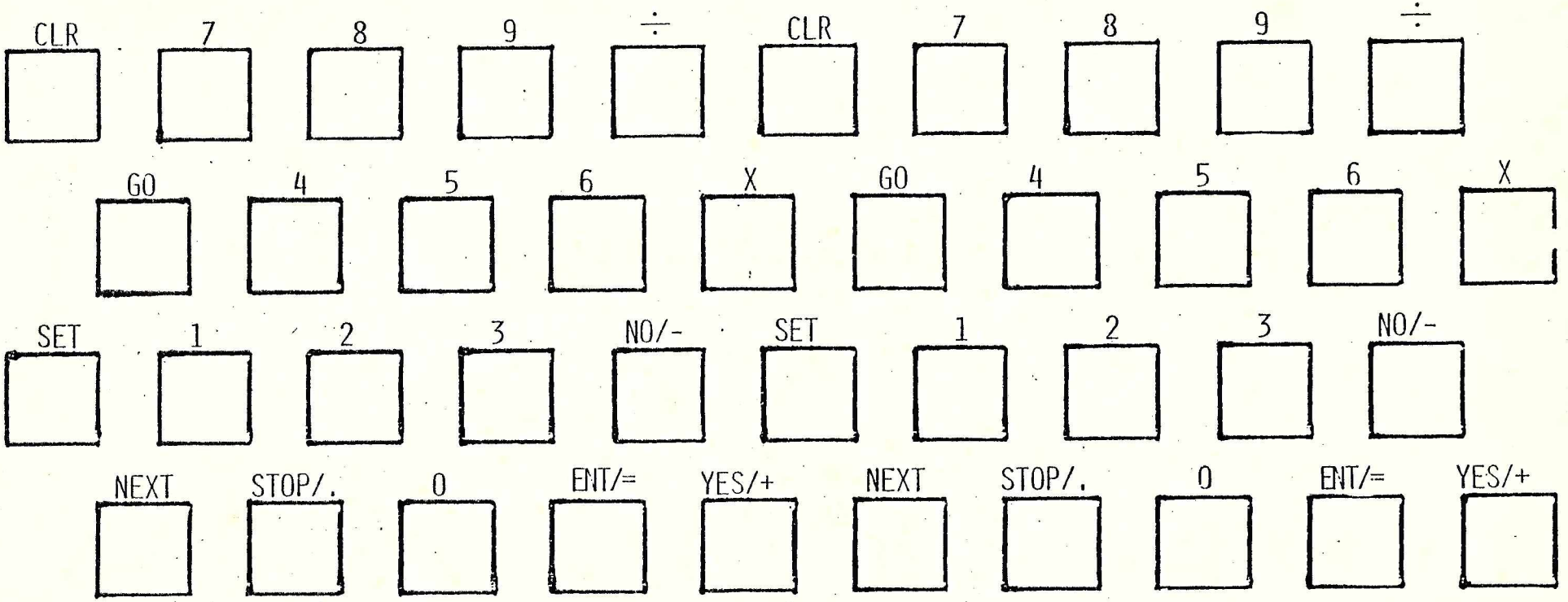
08, Back Space

0A, Line Feed

0D, Return

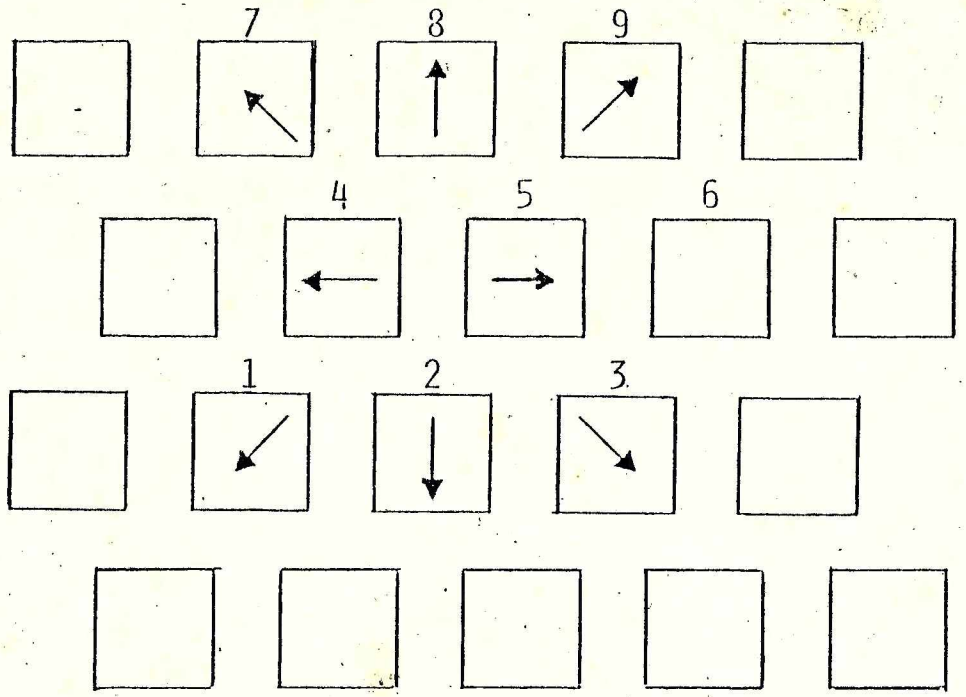
10, DLE

CONSOLE/REMOTE UNIT MAPPING

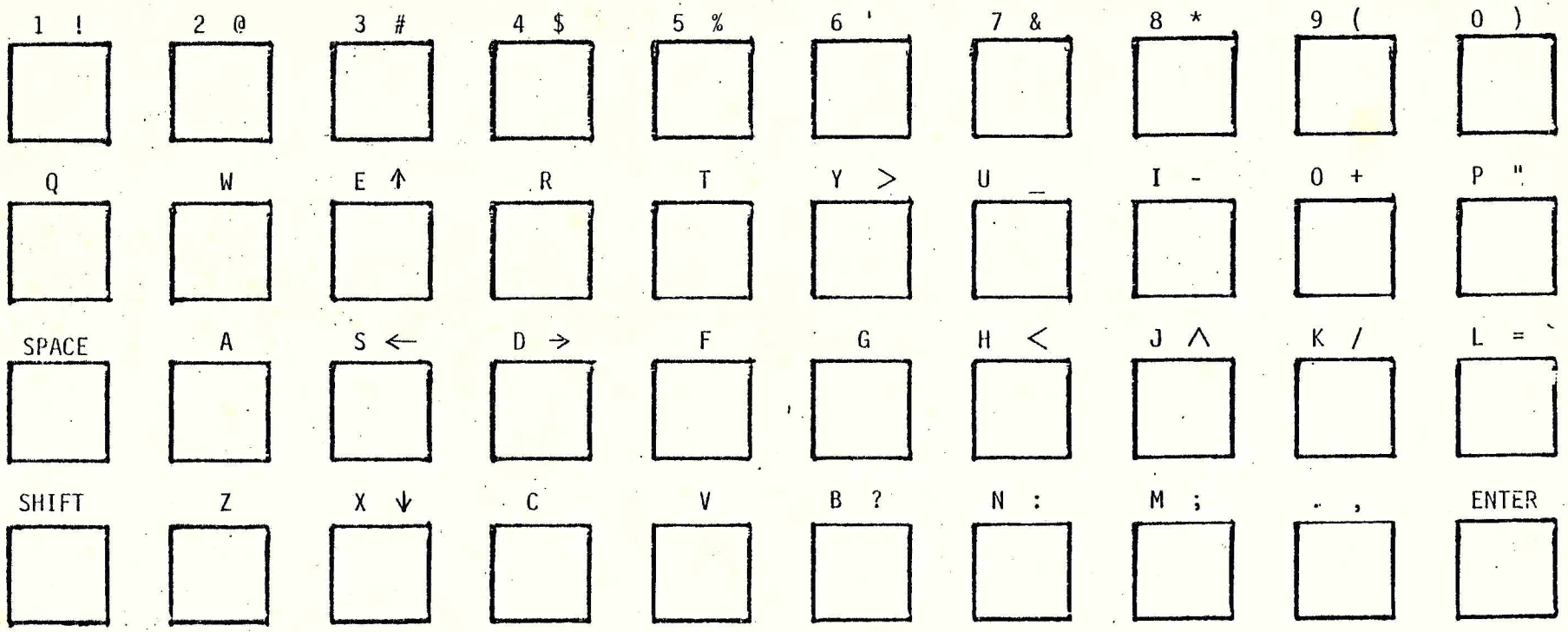


JOYSTICK/CONSOLE MAPPING

KEYBOARD NUMBER	JOYSTICK X,Y CODE
1	C,C
2	0,C
3	4,C
4	C,0
5	4,0
7	C,4
8	0,4
9	4,4
NO KEY	0,0



REMOTE-HANDSET CONSOLE-OVERLAY



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